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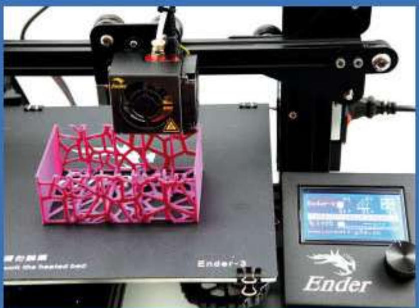

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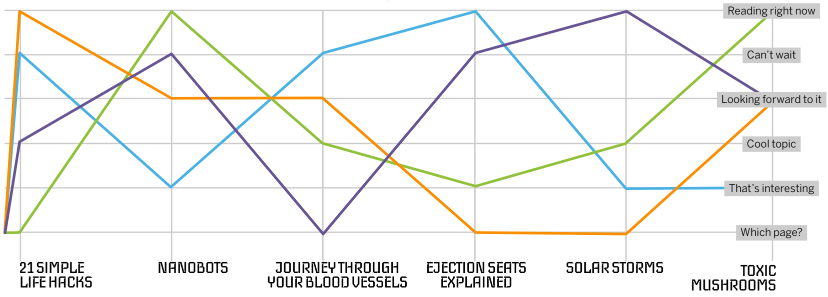
HOW IT WORKS

In 1959, Nobel Prize-winning physicist Richard Feynman talked to a gathering of his peers from the American Physical Society about a concept that would become famous far beyond the sphere of theoretical physics. The lecture was called 'There's Plenty of Room at the Bottom', and in it he imagined a world where vast amounts of information could be processed in tiny spaces and machines too small for the eye to see would perform difficult tasks. This was years before the first computer processor and decades before nanorobotics got started. We've still got a long way to go before we can deploy swarms of tiny robots to do our bidding, but in this issue you'll see how far we've come.

Ben Biggs
EDITOR

WHAT WE'RE ANTICIPATING



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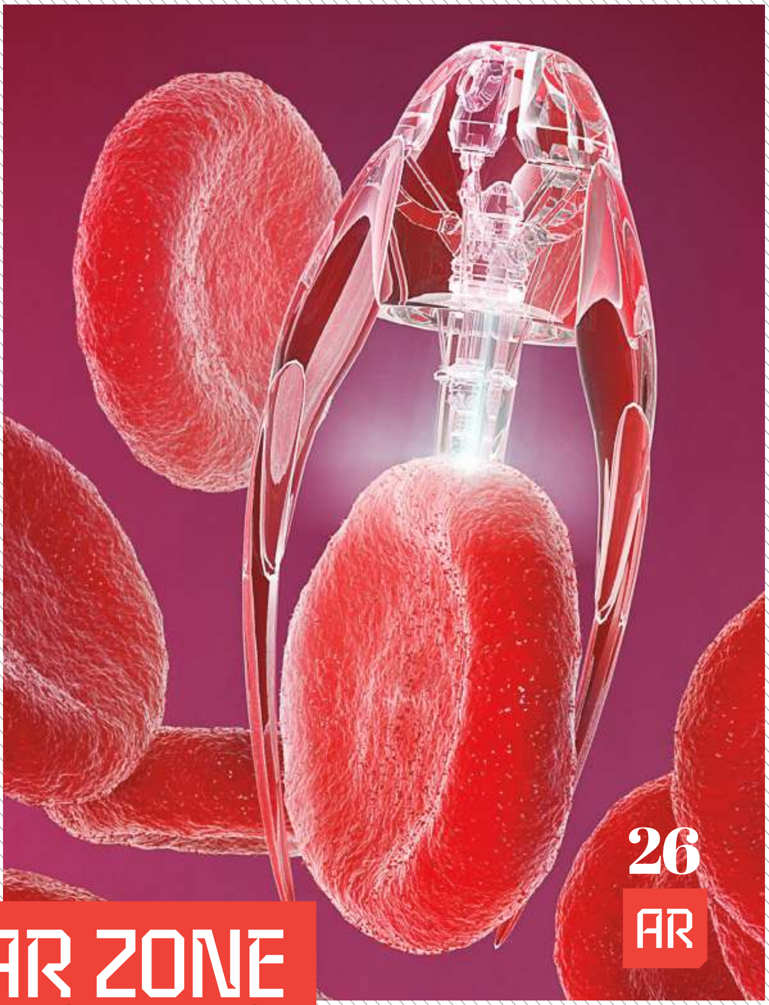

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MEET THIS ISSUE'S EXPERTS

JO ELPHICK
Jo is an academic lawyer and lecturer specialising in criminal law and forensics. She is also the author of a number of true crime books.

MIKE JENNINGS
Mike is a freelance technology journalist who is fascinated with gaming, futuristic technology and motorsport. He dreams of becoming a rally driver.

LAURA MEARS
Biologist Laura escaped the confines of the lab to the rigours of an office desk as a keen science writer and full-time software engineer.

DR ANDREW MAY
Andrew has a PhD in astrophysics and 30 years in public and private industry. He enjoys space writing and is the author of several books.

JAMES HORTON
James works primarily in microbiology. He's an experienced science journalist, having written for a number of science magazines.

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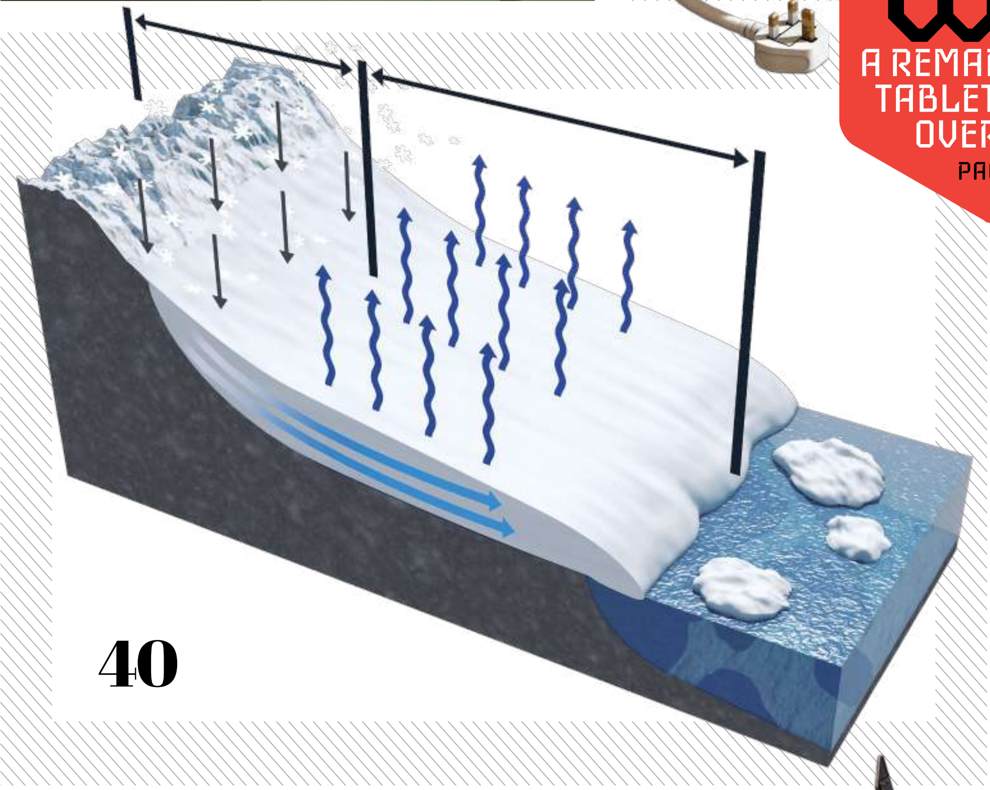

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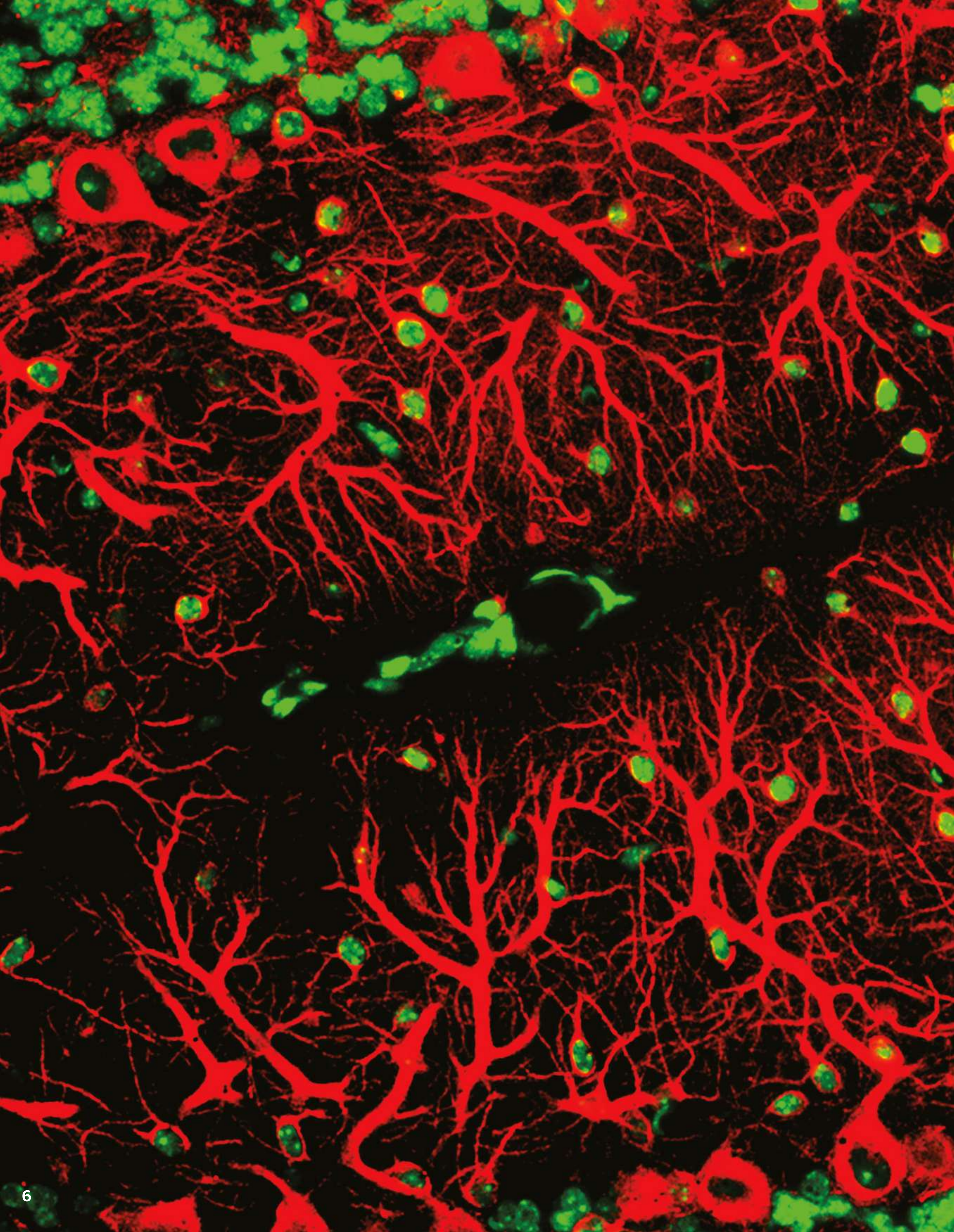

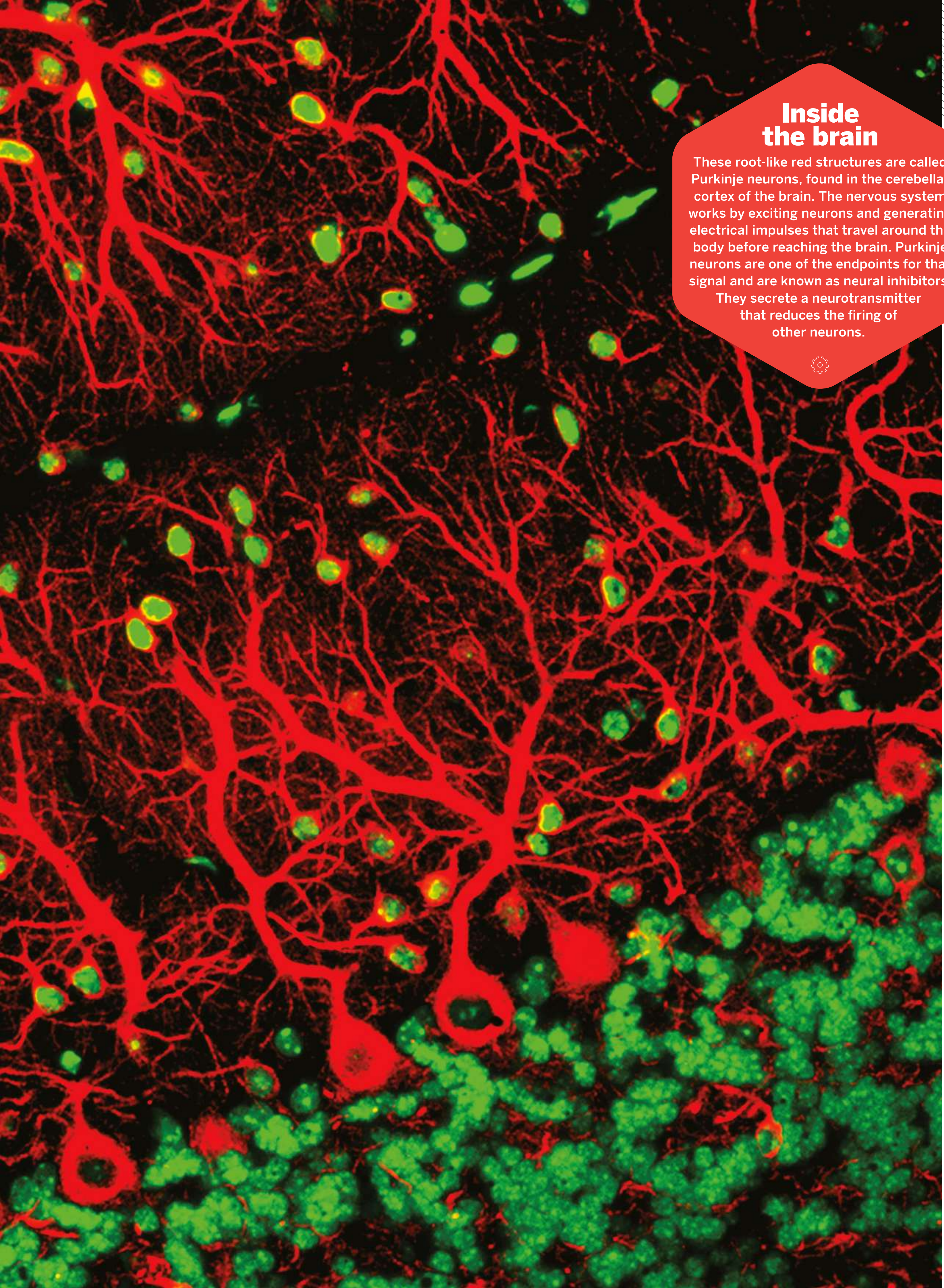

Inside the brain

These root-like red structures are called Purkinje neurons, found in the cerebellar cortex of the brain. The nervous system works by exciting neurons and generating electrical impulses that travel around the body before reaching the brain. Purkinje neurons are one of the endpoints for that signal and are known as neural inhibitors. They secrete a neurotransmitter that reduces the firing of other neurons.

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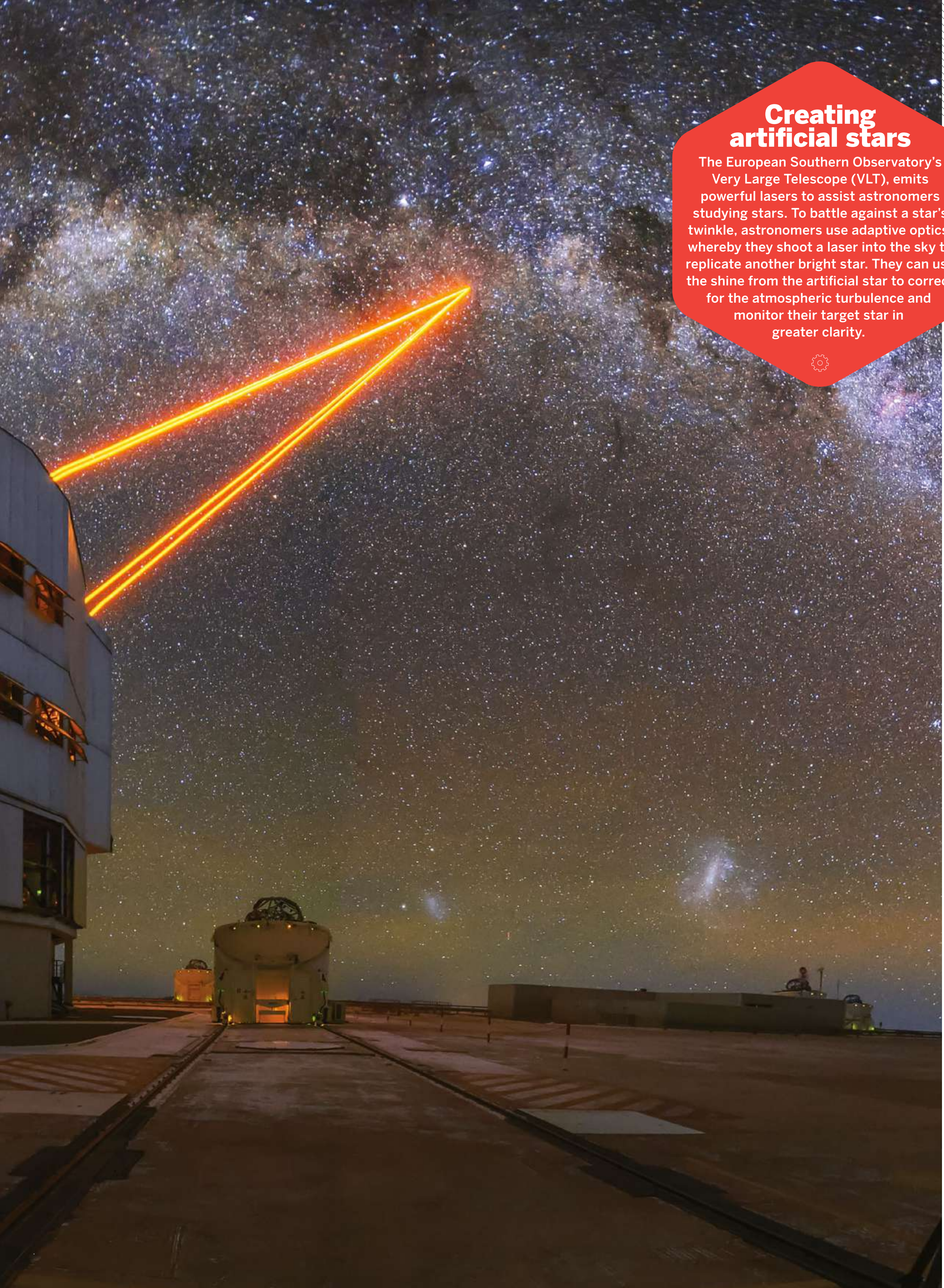


Creating artificial stars

The European Southern Observatory's Very Large Telescope (VLT), emits powerful lasers to assist astronomers studying stars. To battle against a star's twinkle, astronomers use adaptive optics, whereby they shoot a laser into the sky to replicate another bright star. They can use the shine from the artificial star to correct for the atmospheric turbulence and monitor their target star in greater clarity.

© ESO/A. Ghizzi Panizza

Salmon sucker

Meet the salmon louse (*Lepeophtheirus salmonis*), an aquatic parasite that poses a threat to the world's salmon farms. Their prominent mouthparts latch onto a salmon's scales and gills to feed on its blood. Along with salmon, these lice can also infect other salmonid species, such as trout and char. Parasites like these can cause irreversible damage to their host and pass along an array of diseases.

© Getty

Inside the space bubble

Around 7,100 light years from Earth is the Bubble Nebula. It spans seven light years across and at its centre is a star 45 times more massive than our Sun. The central star has lost most of its outer hydrogen and is emitting gas rapidly – at over 4 million miles per hour. These stellar winds of gas create the outer shell of the bubble. The gases are seen in blue for oxygen, green for hydrogen and red for nitrogen.

© NASA Goddard

Fibroblasts labelled with fluorescent dyes

HEALTH

Skin made 30 years younger with a new technique

WORDS **SIDDHI CAMILA LAMA**

Researchers have developed a way to reverse the ageing process in skin cells, turning back the biological clock by about 30 years. De-ageing cells has become increasingly common in the last decade, with researchers reprogramming multiple mouse, rat and human cell types. But never before have cells been de-aged by so many years and still retained their specific type and function. The method, developed by Diljeet Gill, a postdoctoral candidate at the Babraham Institute in Cambridge, and his colleagues has been dubbed 'maturation phase transient reprogramming'.

The researchers applied this technique to fibroblasts, a common type of skin cell, from three middle-aged donors who averaged about 50 years old, then compared them to younger cells from donors aged 20 to 22. The researchers found that the middle-aged cells were similar to the younger cells, both chemically and genetically. When explored further, the team even noticed that the technique had affected genes related to age-related diseases, like Alzheimer's and cataracts. In addition, Gill and his colleagues looked at the behaviour of the fibroblasts to determine if they could also act like younger skin cells. When they wounded a layer of the cells, they found that the rejuvenated cells quickly moved to fill the gap in the same way that younger cells behave when healing wounds.

This study is not the first to de-age skin cells. That title goes to Nobel Prize in Physiology or Medicine winner Shinya Yamanaka, who genetically reprogrammed mouse skin cells and turned them into so-called induced pluripotent stem cells, or iPSCs, back in 2006. These iPSCs resemble cells in early development and have the potential to form any cell type in the body. The new research is based in part on Yamanaka's method, but there are some key differences. Yamanaka's method takes around 50 days and completely reprograms cells to the biological age of an embryo. Gill's method takes just 13 days and only partially reprograms cells so that they still retain their identity – in this case, the identity of skin cells.

While turning mature cells into stem cells is great for research, the complete reprogramming process is not ideal for therapeutics. Completely reprogrammed cells lose their identities and specialised cell functions. And when implanted into the body, these fully reprogrammed cells can become cancerous. In contrast, partially reprogrammed cells, like the skin cells in Gill's research, become biologically younger and retain specialised cell functions, though they could still potentially pose a risk of cancer.

"Our results represent a big step forward in our understanding of cell reprogramming," Gill said. "We have proved that cells can be rejuvenated without losing their function and that rejuvenation looks to restore some function to old cells." While their work is very promising, Gill and his colleagues acknowledge that their paper is a proof-of-concept study. The authors said that they're not sure how fibroblasts from younger or older individuals would react to the new reprogramming method or if cells from people of very different ages would always de-age by 30 years.

Two great white sharks swim beneath the water's surface near Guadalupe Island, Mexico

ANIMALS

SECRET SHARK SOCIAL CLUB DISCOVERED OFF MEXICAN COAST

WORDS **BRANDON SPECKTOR**

Scientists have discovered a great white shark social club in the clear blue waters of Guadalupe Island, off the western coast of Mexico. New research discovered that a group of tagged great whites formed tight cliques during the 2017 and 2018 seasons. They preferred to patrol for food with close buddies or in same-sex pairs, sometimes spending more than an hour swimming together. One pair astonished scientists by spending 70 minutes swimming together. Lengthy interactions like these are likely social associations and not random.

Researchers tagged six great white sharks near Guadalupe Island between October 2017 and December 2018. Dubbed 'super social tags', the monitors tracked each shark's swimming speed, depth and direction, and also alerted researchers any time a tagged shark came into close proximity with another. More than 30 great whites at the island had already been tagged by previous research expeditions, giving researchers plenty of opportunities to see their super social tags in action. Many of the great white interactions occurred near a seal breeding ground, suggesting that perhaps the sharks spend more time with each other when prey is near in order for one shark to take advantage of another's hunting success.

PLANET EARTH

Thousands of new viruses discovered in the ocean

WORDS **RACHAEL RETTNER**

Researchers have analysed tens of thousands of water samples from around the globe hunting for RNA viruses, those that use RNA as their genetic material. These viruses are understudied compared with DNA viruses, which use DNA as their genetic material. The diversity of the newfound viruses was so great that the researchers have proposed doubling the number of taxonomic groups needed to classify RNA viruses from the existing five phyla to ten. "There's so much new diversity here, and an entire phylum, the Taraviricota, were found all over the oceans, which suggests they're ecologically important," said Matthew Sullivan, a professor of microbiology at The Ohio State University.

Studies of RNA viruses have usually focused on those that cause diseases. Some well-known RNA viruses include influenza and Ebola. But these are just a tiny slice of RNA viruses on Earth. "We wanted to study them on a very big scale and explore an environment no one had looked at deeply," said Sullivan. Researchers analysed 35,000 water samples taken from 121 locations in all five of the world's oceans. The researchers are part of the Tara Oceans consortium, a global project to study the impact of climate change on the ocean.

They examined genetic sequences extracted from small aquatic organisms known as plankton, which are common hosts for RNA viruses. They homed in on sequences belonging to RNA viruses by looking for an ancient gene called RdRp, found in all RNA viruses but is absent from other viruses and cells. They identified over 44,000 sequences with this gene.

But the RdRp gene is billions of years old and has evolved many times. Because the gene's evolution goes so far back, it was difficult to determine the evolutionary relationship between the sequences. Researchers used machine learning to help organise them. They identified about 5,500 new RNA virus species that fell into the five existing phyla, as well as the five newly proposed phyla: Taraviricota, Pomiviricota, Paraxenoviricota, Wamoviricota and Arctiviricota. Viruses in the Taraviricota phylum were abundant in temperate and tropical waters, while the Arctiviricota phylum is abundant in the Arctic Ocean. Understanding how the RdRp gene diverged over time could lead to a better understanding of how early life evolved on Earth.

Did you know?

COVID-19 is caused by an RNA virus

More than 5,000 new RNA virus species were identified

© Getty

The rock was found within the Mistastin impact crater in Labrador, Canada, shown here in this satellite image

PLANET EARTH

Massive meteorite impact created the hottest mantle rock ever

WORDS **STEPHANIE PAPPAS**

The hottest rock ever discovered in Earth's crust, a fist-sized piece of black glass, was discovered in 2011 and was formed in temperatures reaching 2,370 degrees Celsius – hotter than much of the Earth's mantle. A new analysis of minerals from the same site revealed that this record-scorching heat was real. The rocks melted and reformed in a meteorite impact about 36 million years ago in what is today Labrador, Canada. The impact formed a 17-mile-wide crater, where Michael Zanetti, then a doctoral student at Washington University in St Louis, picked up the glassy rock during a Canadian Space Agency-funded study of how to coordinate astronauts and rovers working together to explore another planet or moon.

The chance find turned out to be an important one. An analysis of the rock revealed that it contained zircons, extremely durable minerals that crystallise under high heat. The structure of zircons can show how hot it was when they formed. But to confirm the findings, researchers needed to date more than one zircon. In a new study, Gavin Tolometti, a postdoctoral researcher at Western University in Canada, and colleagues analysed four more zircons in samples from the crater. These came from varying types of rocks in different locations, giving a comprehensive view of how the impact heated the ground. One was from a glassy rock formed in the impact, two others from rocks that melted and resolidified and one from a sedimentary rock that held fragments of glass formed in the impact.

Results showed that the impact-glass zircons were formed in at least 2,370-degree-Celsius heat, as previously believed. In addition, the glass-bearing sedimentary rock had been heated to 1,673 degrees Celsius. This broad range will help researchers narrow down places to look for the most super-heated rocks in other craters.

The researchers also found a mineral called reidite within zircon grains from the crater. Reidite forms when zircons undergo high temperatures and pressures. Their presence allowed the researchers to calculate the pressures experienced by the rocks in the impact. They found that the impact introduced pressures of between 30 and 40 gigapascals – just one gigapascal is over 101 million kilograms per square metre of pressure. This would have been the pressure at the edges of the impact. Where the meteorite hit the crust directly, rocks wouldn't have just melted, but vaporised. The findings can be used for other craters on Earth, and elsewhere. The researchers hope to use similar methods to study rocks brought back from impact craters on the Moon during the Apollo missions.

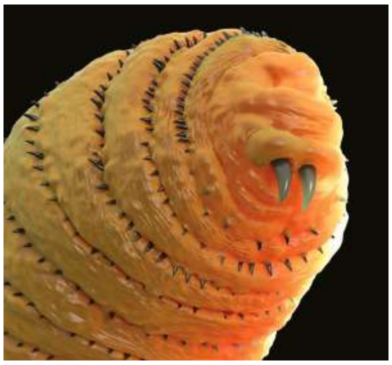
HEALTH

MAN'S 'ITCHY EYE' CAUSED BY SQUIRMING FLY LARVAE

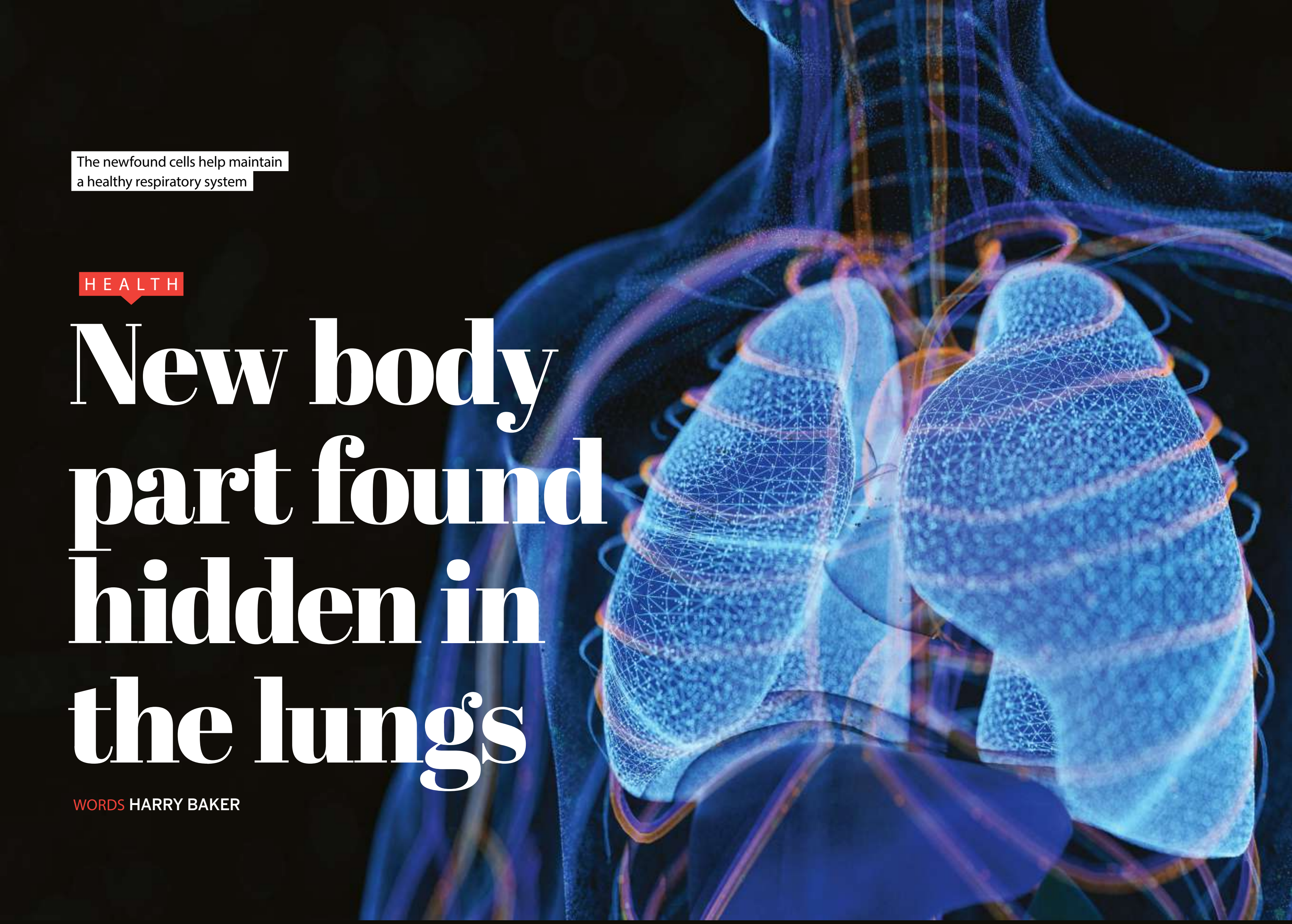
WORDS **RACHAEL RETTNER**

A man's itchy eye was due to more than a dozen fly larvae that were squirming around inside his peeper. The 53-year-old man, who lives in France, went to the emergency room after he developed an itching sensation in his right eye that had lasted several hours. He told doctors that earlier that day he had been gardening near a horse and sheep farm when he felt something enter his eye. When doctors performed an eye exam, they discovered more than a dozen mobile, translucent larvae on the man's cornea and conjunctiva. The cornea is the transparent outer covering at the front of the eye and the conjunctiva is the membrane that lines the eyelid and white part of the eye.

The man was diagnosed with external ophthalmomyiasis, or a larval infestation of the eye. The only way to cure the condition is to physically remove the organisms from the eyeball. In this case, doctors removed the larvae with forceps. The organisms were identified as sheep bot flies, or *Oestrus ovis*, a species of fly that can cause parasitic infections in sheep worldwide. Presumably, the man became infected when a fly flew into his eye and deposited the larvae. At a follow-up appointment ten days later, the man had recovered and did not have any symptoms.



The organisms were identified as sheep bot flies, or *Oestrus ovis*



The newfound cells help maintain a healthy respiratory system

HEALTH

New body part found hidden in the lungs

WORDS **HARRY BAKER**

Scientists have discovered a brand-new type of cell hiding inside the delicate, branching passageways of human lungs. The newfound cells play a vital role in keeping the respiratory system functioning properly and could even inspire new treatments to reverse the effects of certain smoking-related diseases. The cells, known as respiratory airway secretory (RAS) cells, are found in tiny, branching passages known as bronchioles, which are tipped with alveoli, the small air sacs that exchange oxygen and carbon dioxide with the bloodstream. The newfound RAS cells are similar to stem cells – 'blank canvas' cells that can differentiate into any other type of cell in the body – and are capable of repairing damaged alveoli cells and transforming into new ones. Researchers discovered RAS cells after becoming increasingly frustrated by the limitations of relying on the lungs of mice as models for the human respiratory system. To get a better understanding of these differences on a cellular level, the team took lung tissue samples from healthy human donors and analysed the genes within individual cells, revealing the previously unknown RAS cells.

RAS cells serve two main functions in the lungs. Firstly, they secrete molecules that maintain the fluid lining along bronchioles, helping prevent the tiny airways from collapsing and maximising the efficiency of the lungs. Secondly, they can act as progenitor cells for alveolar type II cells, a special type of alveoli that secrete a chemical that's used in part to repair other damaged alveoli. A progenitor cell is a cell that has the capacity to differentiate into another type of cell, similar to how stem cells differentiate into other cells.

"RAS cells are what we've termed facultative progenitors," said Edward Morrisey, a professor at the Perelman School of Medicine at the University of Pennsylvania, "which means they act as both progenitor cells and also have important functional roles in maintaining airway health." This means RAS cells play a vital role in maintaining healthy lungs, he added.

The researchers think RAS cells may play a key role in smoking-related diseases such as chronic obstructive pulmonary disease (COPD). COPD is the result of inflammation of airway passages inside the lungs, which can be caused by smoking and occasionally air pollution. The inflammation of the airways makes it harder for the lungs to properly take in enough oxygen; as a result, COPD has similar symptoms to asthma. In theory, RAS cells should prevent, or at least alleviate, the effects of COPD by repairing damaged alveoli.

However, the researchers suspect that smoking can damage – or even completely destroy – the newfound cells, leading to the onset of diseases such as COPD.

Patients who have COPD are often prescribed anti-inflammatory drugs or oxygen therapy to ease their symptoms. However, these are only temporary solutions and do nothing to reverse lung damage. RAS cells could potentially be used to improve treatments or even cure COPD if researchers can properly harness these cells' regenerative properties. "We really don't know if this discovery could lead to a potential cure for COPD yet," Morrisey said. "However, since COPD is a disease we know very little about, any new insight should help the field start to think about new therapeutic approaches that could lead to better treatments."

Did you know?
Adults breathe in about 11,000 litres of air a day

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SPACE & PHYSICS

DECLASSIFIED DATA REVEALS INTERSTELLAR OBJECT FLYING OVER EARTH

WORDS **BRANDON SPECKTOR**

A fireball that blazed over Papua New Guinea in 2014 was a fast-moving object from another star system. The object, a small meteorite just 0.45 metres across, slammed into Earth's atmosphere on 8 January 2014 after travelling through space at more than 130,000 miles per hour, far exceeding the average velocity of meteors that orbit within the Solar System. A 2019 study argued that the meteor's speed, along with the trajectory of its orbit, proved with 99 per cent certainty that the object had originated far beyond our Solar System – possibly from the deep interior of a planetary system or a star in the thick disc of the Milky Way. But despite the near-certainty, the paper was never peer-reviewed or published in a scientific journal, as data needed to verify calculations was classified by the US government.

Now, government scientists have officially confirmed the findings. In a memo dated 1 March, Lieutenant General John E. Shaw wrote that the 2019 analysis was "sufficiently accurate to confirm an interstellar trajectory." This retroactively makes the 2014 meteor the first interstellar object ever detected in our Solar System. The object's detection predates the discovery of 'Oumuamua – a cigar-shaped object that was also deemed to be moving far too fast to have originated in our Solar System – by three years.

A fireball that flared over Earth in 2014 was a rock from another star system

HISTORY

World's oldest case of cannibalism revealed

WORDS **CAMERON DUKE**

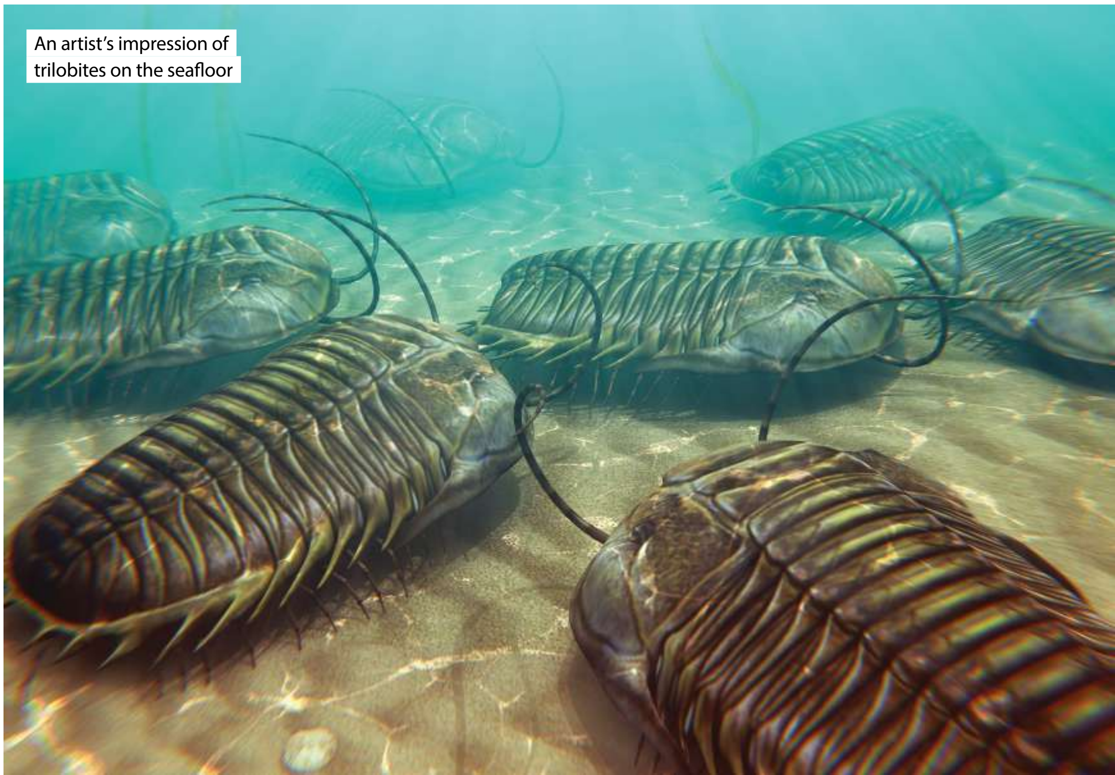
Before there were dinosaurs, there were trilobites brutally biting each other on the Cambrian seafloor. New research has revealed that these armoured predators didn't only hunt smaller and weaker animals for food, but would occasionally take bites out of trilobites of the same species. This finding represents the earliest evidence of cannibalism in the fossil record to date. Trilobites are now-extinct marine arthropods that first appeared in the fossil record around 541 million years ago. They were stout creatures with thick exoskeletons, which is likely one of the reasons so many trilobite fossils remained preserved all these years; exoskeletons fossilise much easier than softer tissues. Russell Bicknell, a palaeontologist at the University of New England in Australia, spent five years examining trilobite fossils from the Emu Bay Shale formation on Kangaroo Island in South Australia. There are two trilobite species from the same genus found in this formation: *Redlichia takooensis*, a deposit feeder that ate particles on the ocean floor, and the larger, predatory *R. rex*.

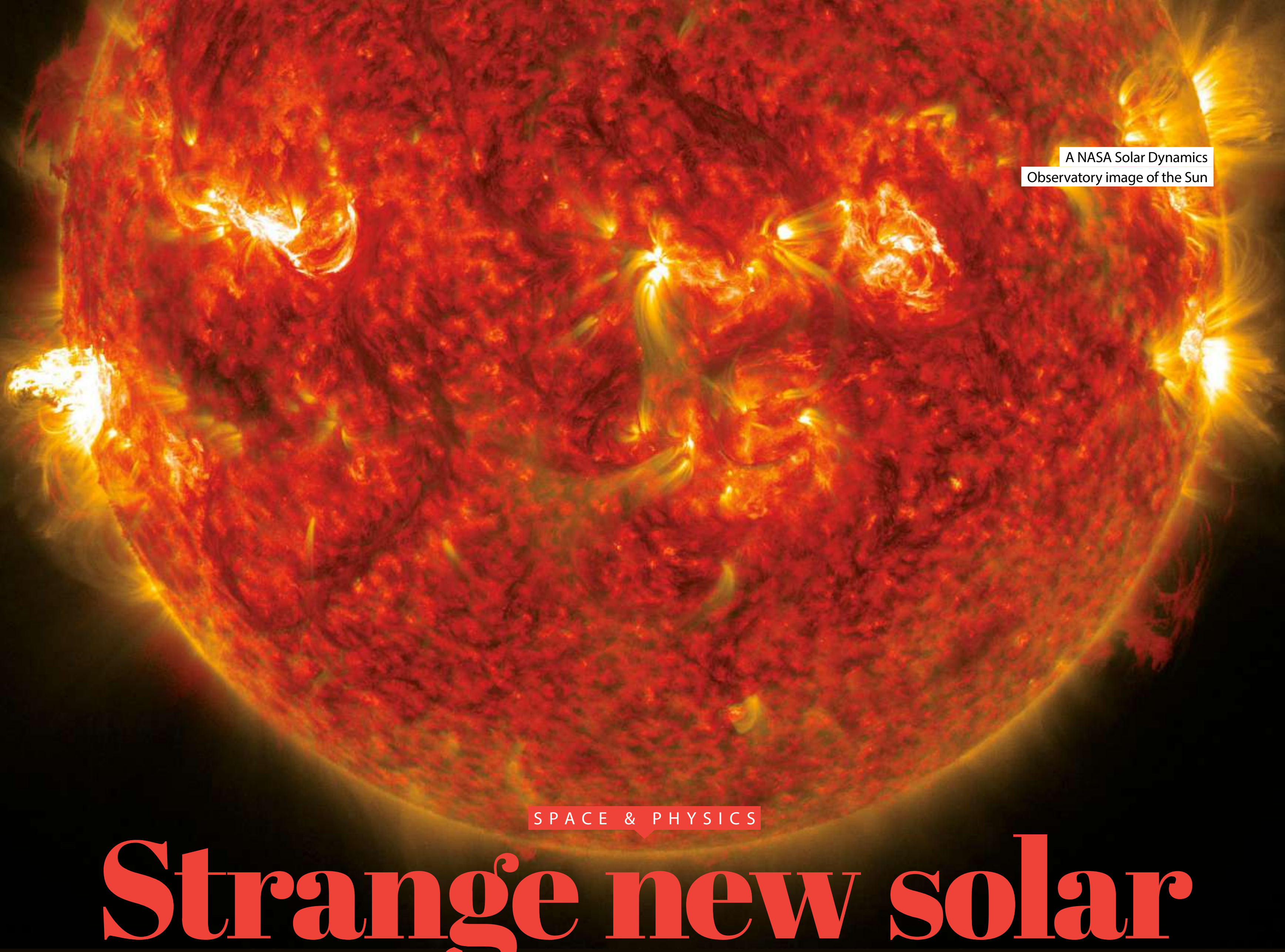
Many fossils were found with what appeared to be bite marks, mostly on their hind ends. This was expected, as palaeontologists already knew that *R. rex* made meals of *R. takooensis*. In the Emu Bay formation, fossilised faeces called coprolite left behind by *R. rex* contain trilobite shell remnants. This suggests that *R. rex* had the capability of eating the smaller trilobite species. What was unexpected were signs of similar bite marks on *R. rex*. These injuries were likely the result of cannibalism. While not much is known about trilobite mouthparts, Bicknell is certain that these injuries weren't 'bites' in the traditional sense. Instead the underside of a trilobite featured two rows of legs, and on these legs were little inward-facing spines.

Most of the injuries seen on the Emu Bay fossils were injuries to the abdomen and not the head. Bicknell believes this is because the injured animals were trying to get away from their predator's clutches, but he also suggests there may have been a bit of survivorship bias at play too. The injured fossils are from the animals that got away – they weren't eaten.

Trilobites that sustained head injuries likely ended up as coprolite. While this is the earliest documented example of cannibalism for any animal in the fossil record, Bicknell said it's likely that cannibalism is much older and more widespread than even these fossils suggest. While it's difficult to prove that cannibalism took place, Bicknell and his colleagues were able to systematically remove all other explanations for the injuries found in *R. rex* fossils.

Did you know?
Hamsters are known to be cannibalistic


An artist's impression of trilobites on the seafloor



A NASA Solar Dynamics Observatory image of the Sun

SPACE & PHYSICS

Strange new solar wave defies physics

WORDS **BEN TURNER**

Scientists have detected a strange new type of high-frequency wave on the Sun's surface, and the waves are moving three times faster than scientists thought was possible. The acoustic waves, called high-frequency retrograde (HFR) vorticity waves, were spotted rippling backwards through the Sun's plasma in the opposite direction of its rotation. Scientists can't see into the Sun's fiery depths, so they often measure the acoustic waves that move across its surface and bounce back towards its core to infer what's going on inside.

But the unprecedented speed of the HFR waves, spotted in 25 years of data from space and ground-based telescopes, has hinted that scientists might be missing something big. "The very existence of HFR modes and their origin is a true mystery and may allude to exciting physics at play," said Shravan Hanasoge, an astrophysicist at New York University Abu Dhabi's Center for Space Science. "It has the potential to shed insight on the otherwise unobservable interior of the Sun."

Scientists initially thought that acoustic solar waves formed near the Sun's surface thanks to the Coriolis effect, in which points on a rotating sphere's equator seem to move faster than points on its poles. Once the waves form, scientists think one of three possible processes could accelerate them into HFR waves – the Sun's magnetic field or gravity could be boosting the Coriolis waves, or superhot convection currents moving under and across its surface could be dragging them to unprecedentedly high speeds. But none of these possible processes fit the data. "If the HFR waves could be attributed to any of these three processes then the finding would have answered some open questions we still have about the Sun," said Chris Hanson, a solar physicist also at New York University Abu Dhabi's Center for Space Science. "However, these new waves don't appear to be a result of these processes, and that's exciting because it leads to a whole new set of questions."

Filling in the gaps in their knowledge might help the researchers better understand the Sun's interior, as well as get a better sense of how the Sun affects Earth and other planets in the Solar System. It could also give insight into a similar type of high-frequency wave, called a Rossby wave, which has been seen traversing Earth's oceans four times faster than current models can explain.

© Getty / NASA SDO

SPACE & PHYSICS

'Magnetic anomalies' may stop the Moon's ice from melting

WORDS BRANDON SPECKTOR

Large craters sit in permanent shadow at the Moon's south pole

In 2018, NASA astronomers found the first evidence of water ice on the Moon. Lurking in the bottom of pitch-black craters at the Moon's north and south poles, the ice was locked in perpetual shadow and had seemingly survived untouched by the Sun's rays, potentially for millions of years. The discovery of water ice came with a fresh mystery, however. While these polar craters are protected from direct sunlight, they are not shielded from the solar wind, waves of charged particles that gush out of the Sun at hundreds of miles a second. This ionised wind is highly erosive and should have destroyed the Moon's ice long ago. Unlike Earth, the Moon no longer has a magnetic shield to protect it from the brunt of these charged particles.

How did the Moon's polar ice survive? A new map of the Moon's south pole – and the strange pockets of magnetic field that lie there – may provide an answer. Scientists from the University of Arizona have shared their map of magnetic anomalies – regions of the lunar surface that contain unusually strong magnetic fields – sprinkled across the Moon's south pole. These anomalies, first detected during the Apollo 15 and 16 missions in the 1970s, are thought to be remnants of the Moon's ancient magnetic shield, which likely disappeared billions of years ago.

The magnetic anomalies overlap with several large polar craters that sit in permanent shadow and may contain ancient ice deposits. These anomalies may be serving as tiny magnetic shields that protect lunar water ice from the constant bombardment of the solar wind. "These anomalies can deflect the solar wind," said Lon Hood, a planetary scientist at the University of Arizona. "We think they could be quite significant in shielding the permanently shadowed regions."

In the new research, the authors combined 12 regional maps of the lunar south pole originally recorded by Japan's Kaguya spacecraft, which orbited the Moon from 2007 to 2009. Included among the spacecraft's science tools was a magnetometer capable of detecting pockets of magnetism across the lunar surface. With their composite map in hand, the researchers saw that magnetic anomalies overlapped with at least two permanently shadowed craters – Shoemaker and Sverdrup – at the lunar south pole. While these anomalies are only a fraction of the strength of Earth's magnetic field, they could still significantly deflect the ion bombardment of the solar wind. That could be the key to the moon's long-lasting water ice.

No one is certain where the Moon's magnetic anomalies came from. One theory is that they date back about 4 billion years, when the Moon still had a magnetic field of its own. When large, iron-rich asteroids crashed into the Moon during this era, they may have created magma surfaces that slowly cooled over hundreds of thousands of years, becoming permanently magnetised by the Moon's magnetic field in the process. Upcoming lunar missions could shed light on the lunar south pole's pitch-dark ice deposits. The Artemis missions, which will ultimately return humans to the lunar surface for the first time since 1972, plan to land astronauts at the lunar south pole and establish a permanent base there. Studying the ice deposits in this region could reveal how they were created and why they've lasted so long.

Did you know?
The solar wind causes aurorae on Earth

1,500 pages of UFO-related research were just declassified as part of a FOIA request

STRANGE NEWS

UFOs left 'radiation burns' and an 'unaccounted-for pregnancy'

WORDS **BRANDON SPECKTOR**

Encounters with UFOs have reportedly left Americans suffering from radiation burns, brain and nervous system damage and even an unaccounted-for pregnancy, according to a massive database of US government reports recently made public through a Freedom of Information Act (FOIA) request. The database of documents includes more than 1,500 pages of UFO-related material from the Advanced Aerospace Threat Identification Program (AATIP), a secretive Department of Defense program that ran from 2007 to 2012. Despite never being classified as secret or top secret, the AATIP only became known to the public in 2017, when former program director Luis Elizondo resigned from the Pentagon and released several now-infamous videos of an unidentified aircraft moving in seemingly impossible ways to the media.

Shortly after AATIP's existence was revealed, a FOIA request was filed for any and all documents related to the program. Four years later, on 5 April 2022, the US Defense Intelligence Agency (DIA) honoured the request by releasing more than 1,574 pages of material.

The cache of documents includes reports on the biological effects of UFO sightings on humans, studies on advanced technologies such as invisibility cloaks and plans for deep-space exploration and colonisation. Some portions of the documents were "withheld in part" for privacy and confidentiality concerns, AATIP said. One standout document from the collection is a report titled *Anomalous Acute and Subacute Field Effects on Human and Biological Tissues*, dated March 2010. The report describes alleged injuries to "human observers by anomalous advanced aerospace systems," some of which may be a "threat to United States interests".

The report describes 42 cases from medical files and 300 'unpublished' cases where humans sustained injuries after alleged encounters with anomalous vehicles, which include UFOs. In some cases, humans showed burn injuries or other conditions related to electromagnetic radiation, the report said – some of them appearing to have been inflicted by 'energy-related propulsion systems'. The report also noted cases of brain damage, nerve damage, heart palpitations and headaches related to anomalous vehicle encounters. It's unclear what kind of vetting process, if any, AATIP used to investigate these alleged cases.

The report also includes a list of alleged biological effects of UFO sightings on human observers between 1873 and 1994, compiled by the Mutual UFO Network (MUFON), a civilian non-profit group that studies reported UFO sightings. The reported effects of UFO encounters include an unaccounted-for pregnancy, apparent abduction, paralysis and experiences of perceived telepathy, teleportation and levitation. The report concludes that there is sufficient evidence "to support a hypothesis that some advanced systems are already deployed and opaque to full US understandings".

SPACE & PHYSICS

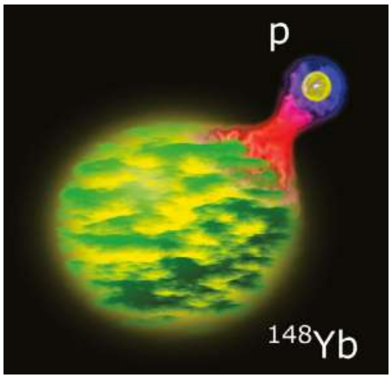
SCIENTISTS CREATE A WEIRD NUCLEUS THAT VANISHES IN NANOSECONDS

WORDS **STEPHANIE PAPPAS**

Physicists in Finland have created a pumpkin-shaped atomic nucleus that throws off protons in a rare kind of radioactive decay. Lutetium-149 has the shortest half-life of any of a group of radioactive elements called proton emitters. It loses half its radioactivity in a mere 450 nanoseconds. Lutetium is a rare-earth element that occurs as a silvery metal with 71 protons and 71 neutrons in its nucleus. It usually occurs alongside the metallic element ytterbium in Earth's crust.

The new isotope, lutetium-149, has 71 protons and 78 neutrons. The scientists found that lutetium-149 was weird. For one thing, its nucleus isn't a neat sphere, but rather a squashed sphere that looks a bit like a pumpkin. This is known as oblate distortion, and lutetium-149 is the most distorted nucleus ever measured. Its tiny half-life is also significantly shorter than isotope lutetium-151's half-life of 80.6 milliseconds.

The researchers created the isotope by firing an isotope of nickel-58 at an isotope of ruthenium-96. The new lutetium isotope decays to ytterbium-148, which itself doesn't stick around for long – it has a half-life of 250 milliseconds.



This artist's impression shows the decay of a lutetium-149 nucleus into a ytterbium-148 nucleus and a proton

© Getty / University of Jyväskylä

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There's probably no better energy-saving gadget than one that can control how much energy you use. The Hive Thermostat is a smart device that gives you total control of your home's heating system. Using the companion app, you can monitor, alter and program the temperature of your home and receive notifications if you've gone out but you've left the heating on behind you. Hive also offers a subscription service for further app analytics that allow you to track your weekly and yearly usage to help you understand when and where you could be saving energy. The Hive Heating Plus subscription also monitors your heating at all times for any abnormalities and early signs of problems. It's worth bearing in mind that this device will require professional installation.

SOLARPANEL 5+

WWW.BIOLITEENERGY.COM

£79.99 / $89.95

The energy consumption of charging smart devices such as smartphones and laptops can be reduced by using alternative charging methods, such as solar panels. There are plenty of portable solar panels out there that can harness the energy from the Sun's rays and turn it into electrical power, and the SolarPanel 5+ by BioLite is a great one. This handheld charger can dispense up to five watts for hours while simultaneously recharging through its solar panel. The panel has an onboard 3,200 milliamp hour battery which allows it to store the excess energy it creates. To maximise its solar efficiency, the panel also comes with a built-in solar dial that helps you correctly align the panel with the Sun. The benefits of this device are limited by the amount of sunlight it's exposed to, but it's a handy energy alternative that can sit on a window ledge or hang from a backpack to keep your smart device charged.

PHILIPS HUE BULBS

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FROM £14.99 / $14.99

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App Control
PHILIPS
hue
white

Philips Hue smart bulbs are fundamentally energy-savvy LED light bulbs that use around 90 per cent less energy than other incandescent bulbs, so without any of their smart features, they're already energy-saving. When used alongside the Hue app, the bulbs can tackle some of the bad habits you might have when it comes to turning lights off. Some of the energy-saving in-app features include Hue's ability to recognise when no one is in the room and turn lights off. The app can also control the brightness of bulbs, along with their colour or tone, and set automatic times the bulbs will turn on and off. You can also group bulbs and other Hue products together to create light profiles and schedules in each room of your home.

radflek
www.radflek.com
radiator reflector
don't heat the street
3 sheet pack
Saves you money
Heat loss reduced by 45%
Just a few minutes to fit

RADFLEK RADIATOR REFLECTORS

WWW.RADFLEK.COM FROM £21.99 (APPROX. $28)

To maximise the efficiency of your radiators' output, Radflek has created these laminated aluminium foil reflectors. Radflek claims that they reflect 95 per cent of the wasted heat energy emitted from radiators. They work by preventing the wall behind the radiator from absorbing heat and reflecting it back inside the room.

What's handy about these foil reflectors is that you don't need to remove your radiator or hire a professional to install them. The reflectors easily hang from the wall brackets behind the radiator and take only a few minutes to install. Because they hang behind the radiator, they are also concealed from view. At a time when people are concerned about their heating bills and energy usage, these reflectors are a good way to make sure you're getting as much heating for your money as possible, potentially reducing the amount of energy needed to heat your home.

Living Room
Good Morning
Arrive Home
Eve Energy
Eve Light Strip
eve

EVE ENERGY

WWW.EVEHOME.COM £39.95 / $39.95

Smart plugs are a great way to save energy. This app-controlled plug by Eve gives you complete control of your household electronics. By using the Eve smart plug and its companion app, you can control the power supply to any of the connected devices or appliances, as well as setting a schedule for automatic switch-on. You can also monitor the energy output of your devices using the app's built-in analytics. The data collected by these smart plugs can provide a projected cost of your appliances based on your electricity rate. Eve is only as efficient as the person who's using it, but it offers the information you need to accurately monitor your energy output and identify areas of energy consumption that you can eliminate or alter.

DRY:SOON HEATED AIRER & COVER

WWW.LAKELAND.CO.UK £179.98 (APPROX. $229)

Many drying machines can be heavy and energy-draining, therefore using alternative devices could curb your energy consumption. The Dry:Soon heated airer from Lakeland is a nifty clothes horse that releases warm air over your freshly washed clothes to dry them out. To speed up the drying process, the Dry:Soon is bundled with a cover to improve the performance of the heater. The heater can hold up to 15 kilograms of washing on a collective 21 metres of drying space. It operates at 0.3 kilowatt-hours, whereas a drying machine is anywhere between two and six kilowatt-hours. The Dry:Soon does take considerably longer to dry clothes than a traditional dryer, but it still uses less energy. Along with using less energy than many drying machines, this heater is also a lot gentler on your clothes.

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+ HOW GLACIERS FORM
CAR VENDING MACHINES
EXPLORE YOUR VEINS AND ARTERIES
WHAT A SOLAR STORM DOES TO EARTH
WEIRD LIFE CYCLE OF THE ANGLERFISH
HOW DOES ALCOHOL MAKE US DRUNK?
WHAT IS NANOTECH?
Enter the invisible world of tiny machines and materials, where everything measures 0.0001 millimetres or less

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NANO

DID YOU KNOW? Researchers are designing salt-based nanoparticles that make clouds form in the sky

WHAT IS TECH?

Enter the invisible world of tiny machines and materials, where everything measures 0.0001 millimetres or less

WORDS **LAURA MEARS**

© Getty

The smallest object visible to the naked eye is a human egg cell. It measures just 0.1 millimetres in length. Beyond that limit, the world is completely invisible. Nanotechnology is the field of science and engineering at a scale of one to a hundred nanometres. That's a thousand to a hundred thousand times smaller than the smallest thing we can see.

Particles at this tiny scale behave completely differently to the full-size structures we are used to. Gold changes colour from yellow to purple and becomes liquid at room temperature. Carbon transforms into an extraordinary electrical conductor. And copper gains the ability to kill bacteria. Discovering this invisible world and harnessing its power is the domain of nanotechnology.

Did you know?

Nanofibres can filter pollutants from indoor air

The first person to measure and name a nanoparticle was Richard Zsigmondy. Awarded the Nobel Prize in Chemistry in 1925 for his efforts, he was fascinated by ceramics and glass. Their stunning colours were the result of nanoscale particles known as colloidal gold, which reflect light in unusual ways. But it wasn't until the 1950s that people started to experiment with using nanoparticles like these in different ways. During the Cold War, another Nobel Prize winner, Richard Feynman, was investigating the possibility of science on an atomic scale. He published a paper entitled *There's Plenty of Room at the Bottom*, inviting scientists to enter a new field of physics. Feynman wanted to miniaturise computers and create machines that could assemble molecules atom by atom. And he dreamed of a day when you could 'swallow your surgeon', delivering a life-saving robot into your body.

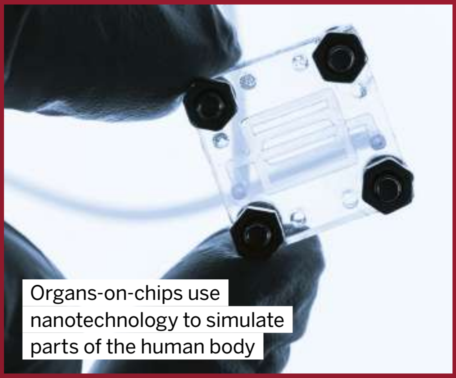
His ideas might sound like science fiction, but nature had already proven they were possible. Inside every single cell there are millions of molecules, each measuring just fractions of a millimetre across. These particles can perform both mechanical and chemical work; they self-assemble and self-heal, and they also store and exchange information. They are nature's nanomachines – all we have to do is recreate them.

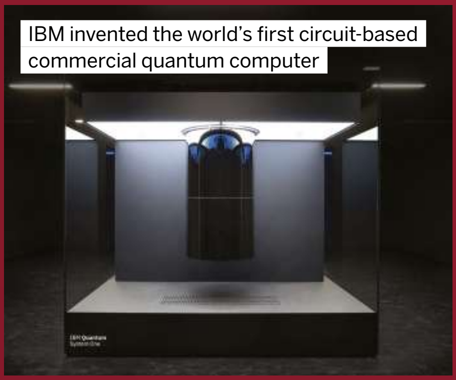
In the 1980s, two powerful new microscopes revealed the nanoworld in all its minute detail. The scanning tunnelling microscope used a very fine wire and an electric current to map even the thinnest of materials. At nanoscale, electrons behave like waves, allowing them to pass through solid objects using a technique called tunnelling.

The atomic force microscope worked in a similar way, but used a silicone tip and a laser to trace the surface of a sample. It could tell researchers about the magnetic, electrical, chemical and physical properties of materials they could never hope to see with their own eyes.

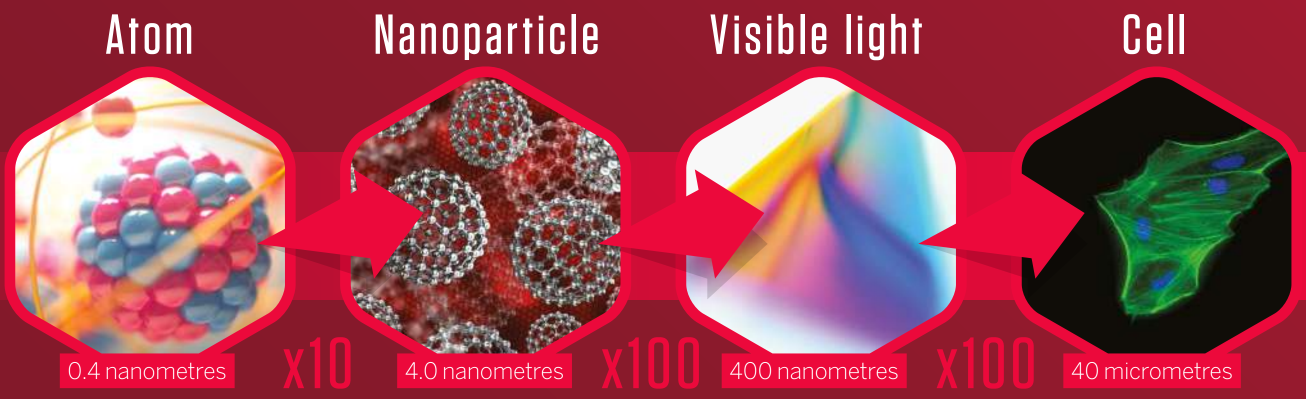
By the 1990s the field had exploded. Researchers observed carbon nanotubes for the first time – just a single atom thick, they were stronger than steel. In the years that followed, scientists developed the ability to fold DNA like paper, and they discovered that it was possible to guide nanoparticles inside the body like homing missiles. Now, with science advancing at lightning speed, Feynman's dreams are closer than ever.

Factories make graphene by forcing ions between layers of graphite to peel them apart

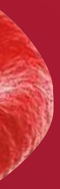

Organs-on-chips use nanotechnology to simulate parts of the human body


IBM invented the world's first circuit-based commercial quantum computer

NANO SCALE



DID YOU KNOW? Nanoscale platinum particles have the potential to make lateral flow tests 100 times more sensitive

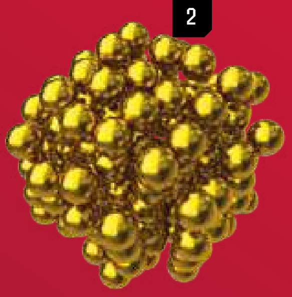


TYPES OF NANOMATERIALS

Each of these small-scale particles has the potential to change the world

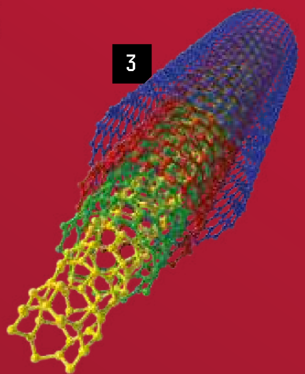
1 MICELLE

These self-assembling structures have an outer water-loving shell and an inner water-hating core. They can help stubborn chemicals dissolve by shielding them from water, potentially aiding drug delivery.



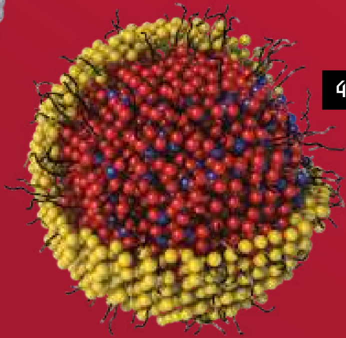
2 GOLD

Made from an inert precious metal, these nanoparticles show promise in medical treatment. They can carry chemicals and genetic material to precise locations inside the body without causing any harm.



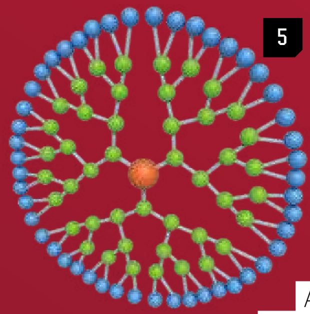
3 CARBON NANOTUBE

These large-scale nanoparticles form hollow rods one atom thick and with a tensile strength greater than steel. They have potential applications in everything from display screens to artificial limbs.



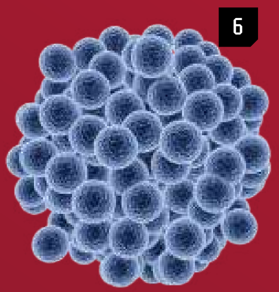
4 QUANTUM DOT

Also known as artificial atoms, these nanoparticles have a crystal structure. They are tiny semiconductors with the ability to absorb photons and emit light, making them attractive for display technology.



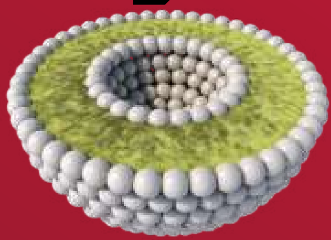
5 DENDRIMER

These symmetrical nanoparticles have arms that look a bit like the branches of trees. They can carry molecules inside their cores, making them a possible delivery vehicle for cancer treatments.



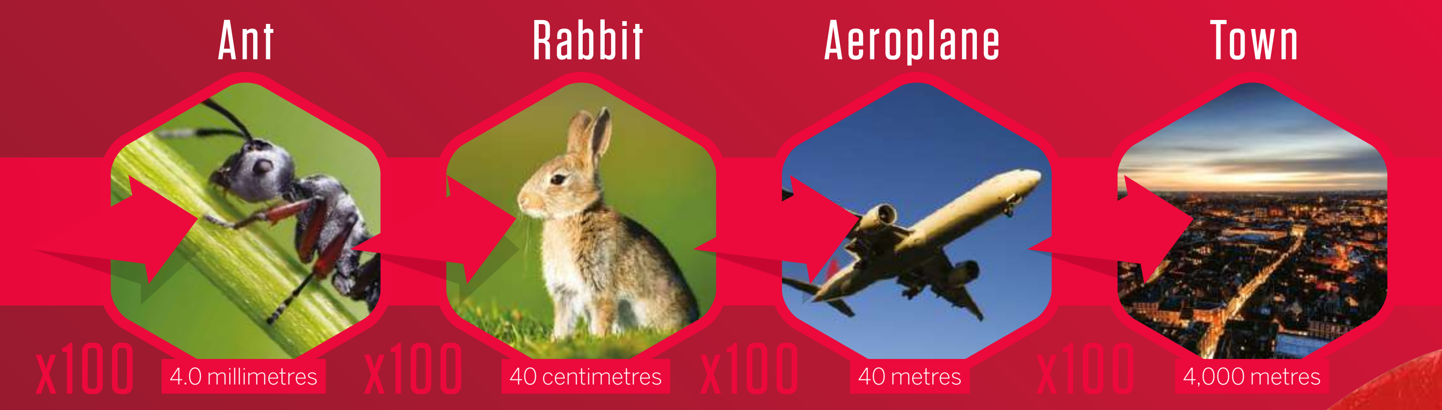
6 MAGNETIC

Made from iron oxide, these nanoparticles have all the properties of a full-sized magnetic material. They show promise in medical diagnosis and treatment because magnets can guide them into position.



7 LIPOSOME

These little spheres can carry cargo into living cells. Made from cholesterol and fats called phospholipids, they could help deliver drugs that wouldn't normally be able to cross the cell membrane.



AR zone

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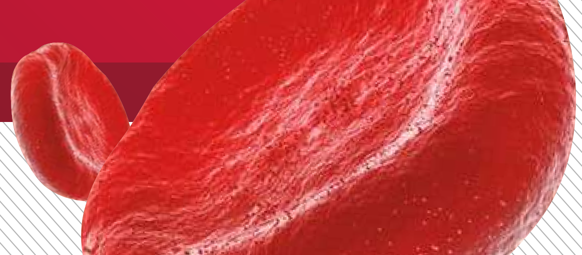

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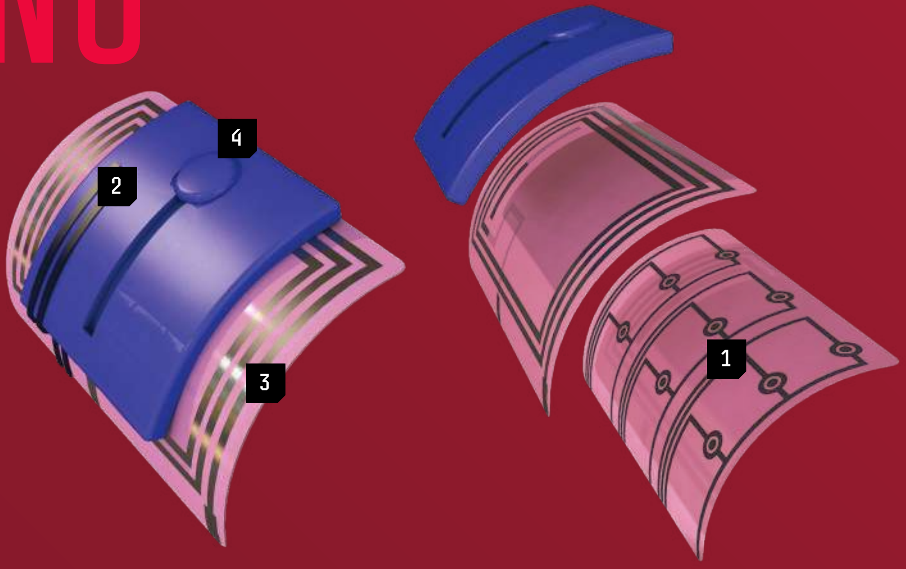
Cell-sized robots could revolutionise medical diagnosis and treatment

INTRODUCING NANOBOTS

Nanobots are robots on a molecular scale. Smaller than a grain of sand, these programmable particles take inspiration from biology. Inside every living cell are tiny machines that are surprisingly like the machines we use in our everyday lives. There are pumps, motors, switches and even clocks, all working together to perform complex work in miniature. Researchers have taken inspiration from these machines to create brand-new technology from tiny component parts. Made from proteins, fat and even DNA, nanobots have the potential to perform tasks like delivering drugs, killing bacteria and inactivating toxins. Some of the most promising use a design pattern called DNA origami. Made from repeating units of genetic code, these tiny particles can self-assemble into geometric shapes. They can form hollow cubes, rod-like scaffolding and even gears. In the future, particles like these could recreate mechanical machines on a nanoscale.

Did you know?

Metal nanoparticles can kill microbes on contact



WEARABLE NANOPATCHES

Skin-mounted sensors can detect deadly gases, monitor the body or deliver life-saving drugs

1 SENSOR ARRAY
Miniature sensors can detect anything from touch and temperature to chemicals in the air.

2 FLEXIBLE MATERIALS
Nanomaterials mixed with fabrics or polymers create flexible sheets that can move with the body.

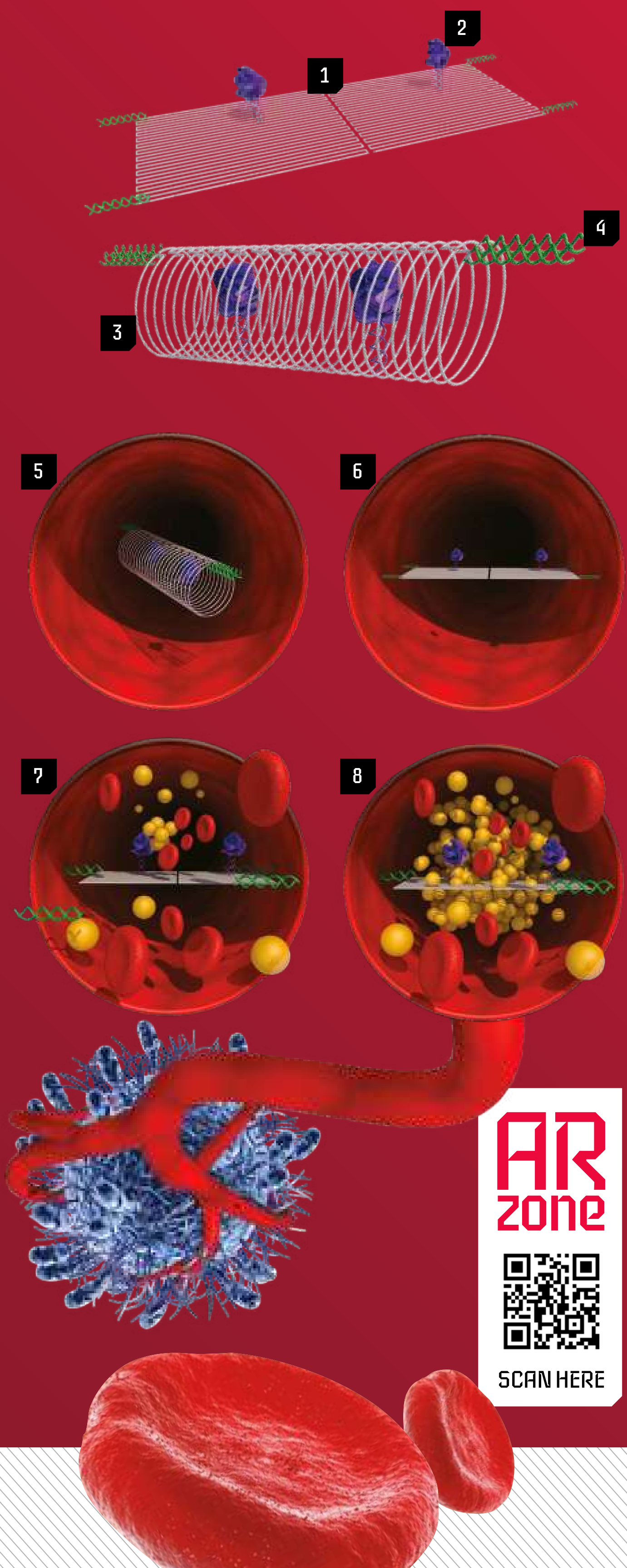
3 SELF-POWERED
Nanogenerators harvest electricity from friction, heat, sound, vibration and even wind or blood flow.

4 DRUG DELIVERY
Patch-mounted pumps can deliver life-saving treatments, like insulin for diabetes.

DID YOU KNOW? Laser-activated nanomaterials could kill cancer cells and deliver antibiotics at the same time

FIGHTING CANCER WITH NANOBOTS

Miniature robots from Arizona State University destroy tumours by cutting off their blood supply



AR zone

SCAN HERE

1 DNA SHEETS
Flat, rectangular sheets of DNA form the basic scaffolding of the nanobots.

2 THROMBIN
The sheets carry a protein called thrombin, which causes blood to clot.

3 ORIGAMI
The DNA folds over to form a tube around the thrombin.

4 HOMING SIGNAL
Fragments of DNA at the edges of the sheet guide the nanobots to molecules found on the surface of cancer cells.

5 INSIDE THE BODY
Each nanobot measures just 60 nanometres in length, allowing it to fit easily into tiny blood vessels.

6 TROJAN HORSE
When the nanobots reach the tumour they uncurl, revealing the thrombin proteins hidden inside.

7 CLOTTING BEGINS
The blood starts to clot around the nanobots, sticking together to form a solid plug.

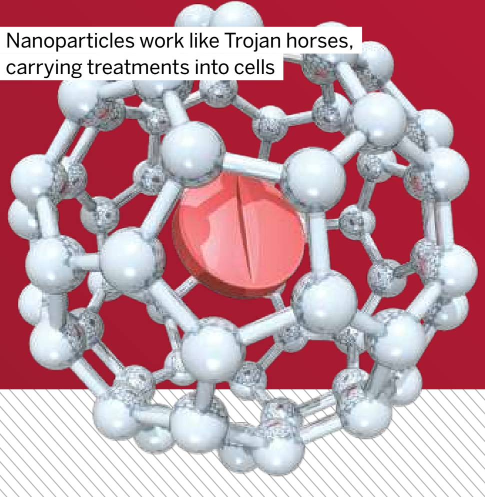
8 TISSUE DAMAGE
Within 24 hours, the clot blocks the blood supply to the tumour, killing the cancer cells.

NANODENTISTRY

Nanobots have the potential to revolutionise dentistry. Performing surgery in the mouth is difficult. There isn't a lot of room to move around, and there are lots of vital tissues, nerves and blood vessels close together. In the future, nanobots could travel through the gums and deliver anaesthetic directly to an individual tooth, without the need for needles. They could use nanoparticles made from the bone mineral hydroxyapatite to repair cavities and jaw damage. And they could even destroy harmful bacteria. Future nanodentistry could also include high-tech mouthwash or toothpaste to deliver a protective nanocoating to shield teeth from plaque and tartar.

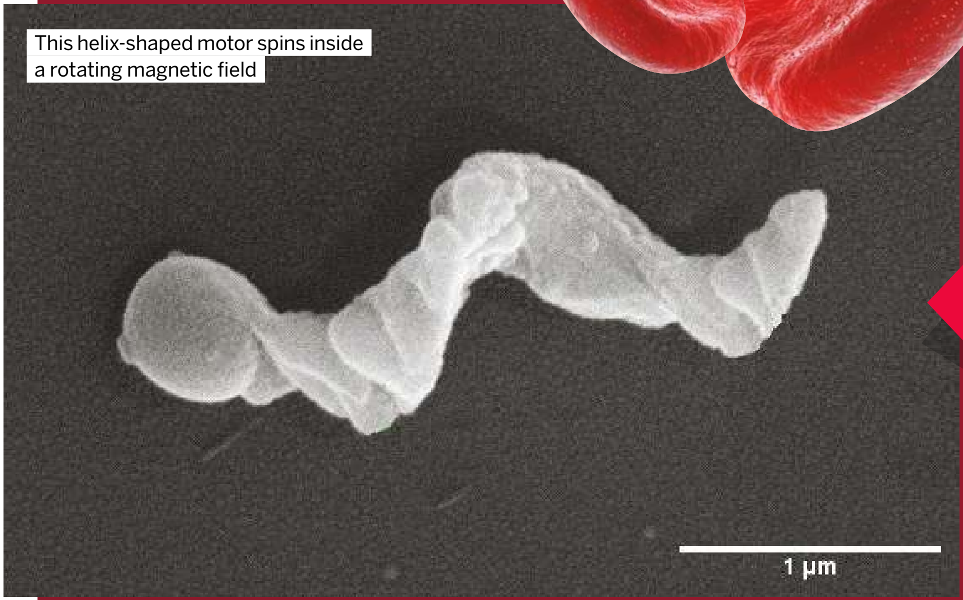
Nanotechnology could make dentistry painless and precise in the future

Electrospun nanofibres could make ultra-fine virus filters for masks



Nanoparticles work like Trojan horses, carrying treatments into cells

© Getty / Illustrations by Adrian Mann



This helix-shaped motor spins inside a rotating magnetic field

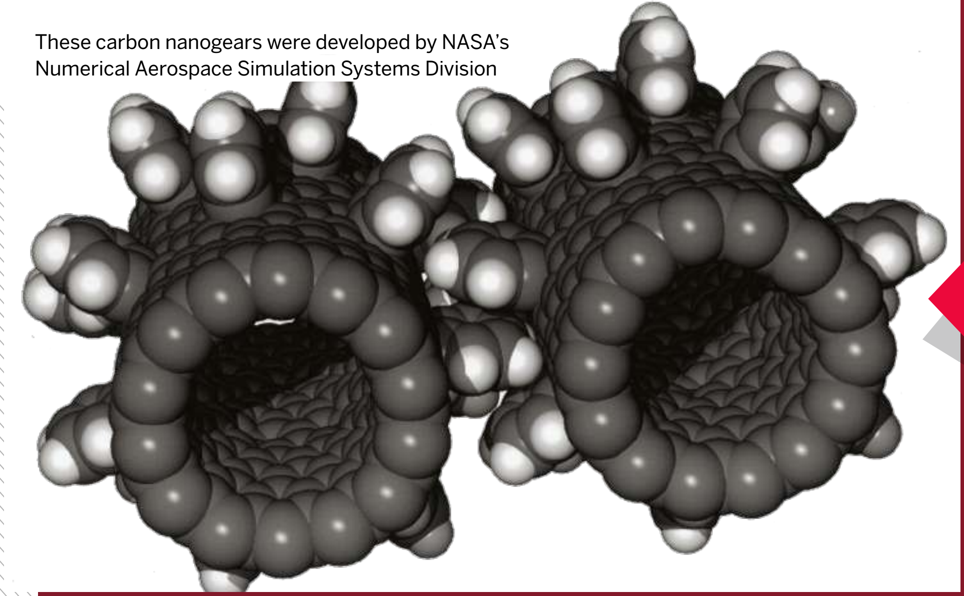
MAGNETIC NANOBOTS

Magnetic nanoparticles respond to external magnetic fields. This makes it possible to guide them through space, opening the way for magnet-driven nanobots. Researchers have found that applying different types of magnetic fields can make the tiny robots move in different ways. A rotating magnetic field can make a helical robot spin, winding forward like spring. An oscillating magnetic field can make a nanobot undulate, curling up and down like a fish. And a stepping magnetic field can make it stop and start like a switch, allowing a nanobot's limbs to perform rowing movements. It's also possible to combine magnetic control with other types of input, like light or ultrasound. This could one day allow much finer control of a nanobot's movement, allowing it to perform highly complex and extremely delicate tasks, like surgery.

DNA-sized transistors like those on this silicon wafer could one day allow computers to fit inside cells

ULTRA-POWERFUL COMPUTERS

Computers think in zeros and ones. They contain millions of tiny switches, called transistors, that can be either on (one) or off (zero). The more transistors a computer has, the faster it can think. For the past few decades, engineers have been working hard to make this technology as small as possible. As a result, the number of transistors that can fit on a computer chip has roughly doubled every two years – a phenomenon known as Moore's law. Your average computer now contains transistors no bigger than 14 nanometres across, while the most advanced contain transistors that measure just seven nanometres. In 2022, IBM unveiled transistors that measure just two nanometres, thinner than a strand of DNA, making it possible to pack 50 billion onto a chip the size of your fingernail.



These carbon nanogears were developed by NASA's Numerical Aerospace Simulation Systems Division

FULLERENE MACHINES

In 2016, three chemists received the Nobel Prize for developing the world's smallest machines. They had invented chains, axles and motors on a molecular scale. These advances led to the development of the world's first nanocar in 2005, a moving vehicle 20,000 times smaller than the width of a human hair. The car had wheels made from buckyballs and axles that moved freely, allowing the whole structure to roll. By 2017, researchers were literally racing to develop the next generation of nanoautomobiles. The world's first nanocar race was held in France, using a scanning tunnelling microscope to propel six of the world's smallest cars towards the finish line. These experiments are good for more than just entertainment, however. They could one day lead to programmable machines capable of performing mechanical work on a miniature scale.

DID YOU KNOW? In 1990, IBM engineers carefully positioned 35 xenon atoms to spell out the company logo on a nanoscale

5 FACTS

NANOTECH THAT ALREADY EXISTS

1 COMPUTER PROCESSORS
The processor that powers your computer or your phone contains hundreds of tiny switches called transistors. Each one measures less than ten nanometres across.

2 QUANTUM DISPLAYS
Ultra-high-definition QLED screens contain tiny nanocrystals called quantum dots – the Q in QLED stands for quantum. They contain nanoscale semiconductors that emit different coloured light depending on their size.

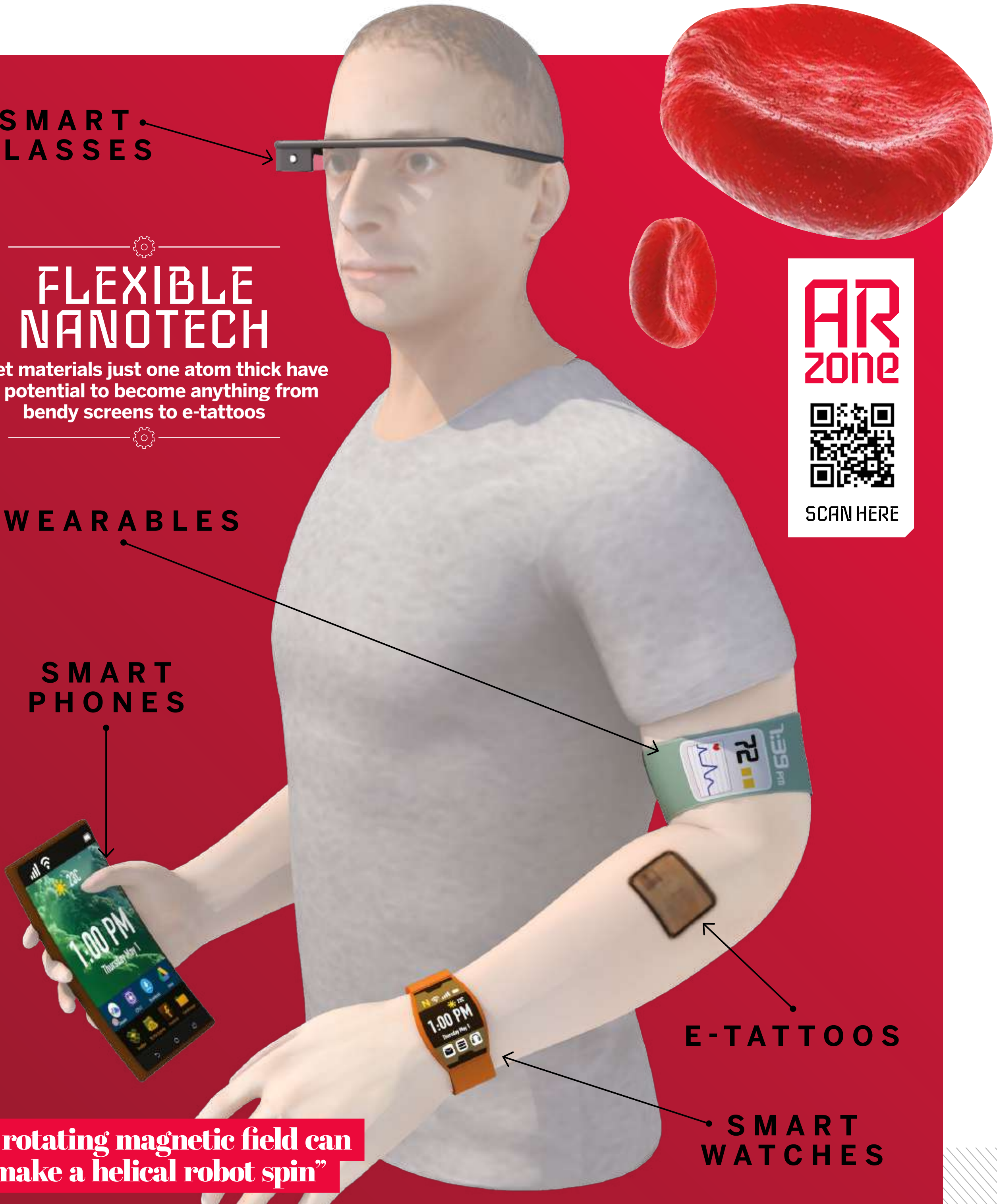
3 MOLECULAR PRINTERS
It's now possible to 3D print at nanoscale using an AI-powered scanning tunnelling microscope. The powerful piece of kit can pick up and lay down molecular building blocks.

4 FLEXIBLE SCREENS
Advances in nanotechnology have made it possible to bend, roll and even fold electronic screens. They use flexible plastic polymers and ultrafine conductive materials like graphene or silver nanowires.

5 SELF-HEALING PLASTIC
New types of plastic combine flexible paint-like materials with tough nanoscale polymers to allow tears and breaks to self-heal. The process even works under water.

FLEXIBLE NANOTECH

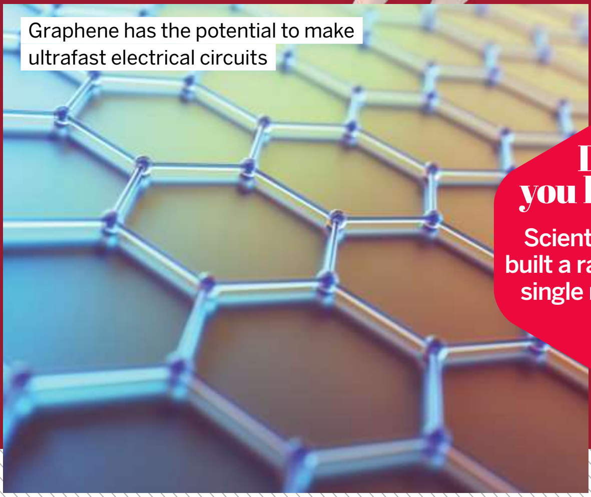
Sheet materials just one atom thick have the potential to become anything from bendy screens to e-tattoos

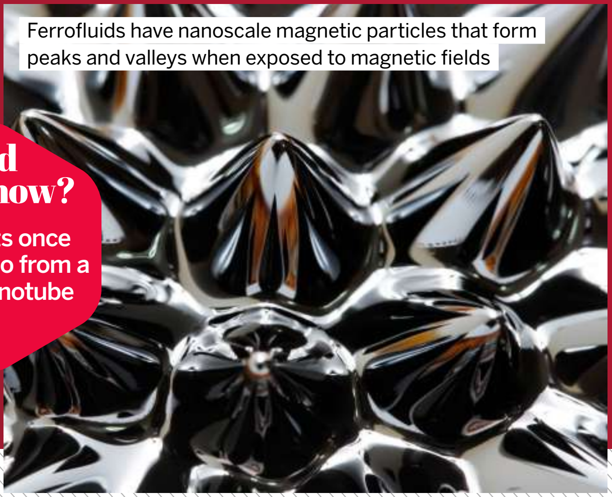


AR zone

SCAN HERE

> "A rotating magnetic field can make a helical robot spin"

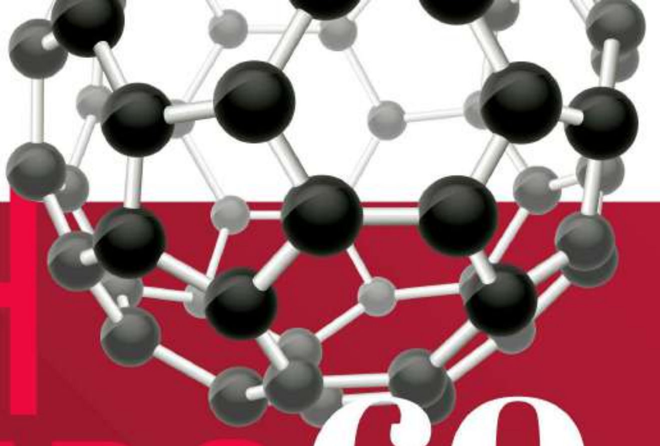

Graphene has the potential to make ultrafast electrical circuits


Ferrofluids have nanoscale magnetic particles that form peaks and valleys when exposed to magnetic fields

Did you know?
Scientists once built a radio from a single nanotube

© Getty / NASA / David Alterman / Illustrations by Adrian Mann

NANOTECH BY NUMBERS



60

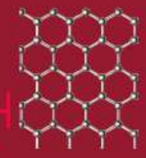
A buckyball contains this many carbon atoms

60,000 NANOMETRES

The width of a human hair

1.3 NANOMETRES

The height of the smallest water container; it holds two molecules



1994

The year graphene was discovered

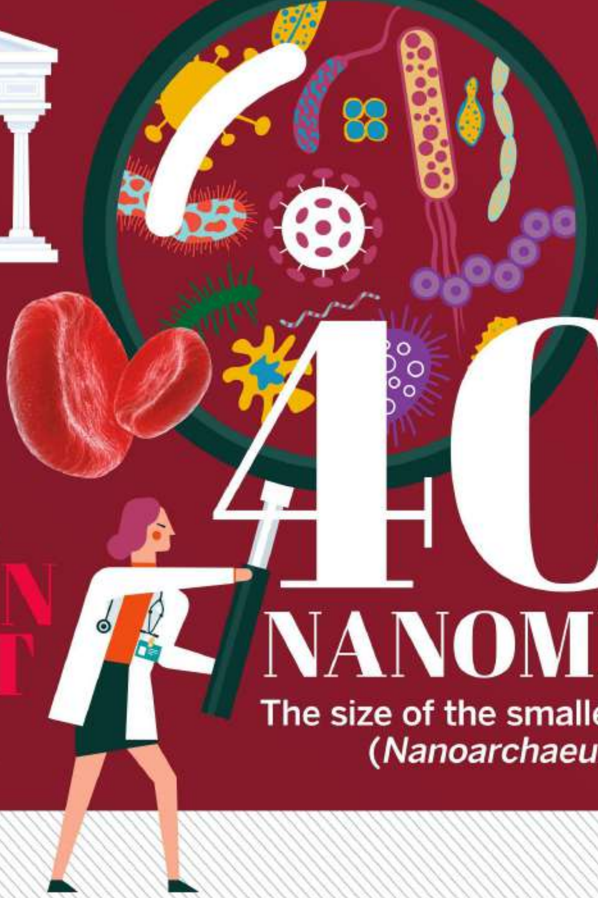
15 BILLION

Number of transistors in the processor of the iPhone 13

0.3 NANOMETRES

The letters SU, for Stanford University, are the smallest ever written

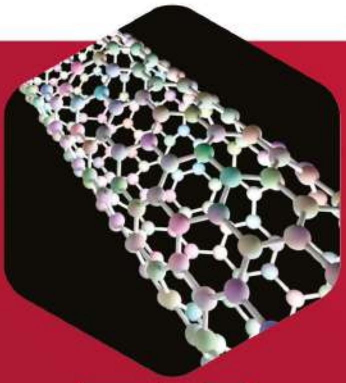
THE WORD 'NANO' MEANS DWARF IN ANCIENT GREEK



400 NANOMETRES

The size of the smallest living organism (*Nanoarchaeum equitans*)

DID YOU KNOW? Antimicrobial metal nanomaterials can stop marine life growing on the hulls of boats, preventing damage at sea



50

CENTIMETRES

The longest carbon nanotube was around 500 million nanometres long

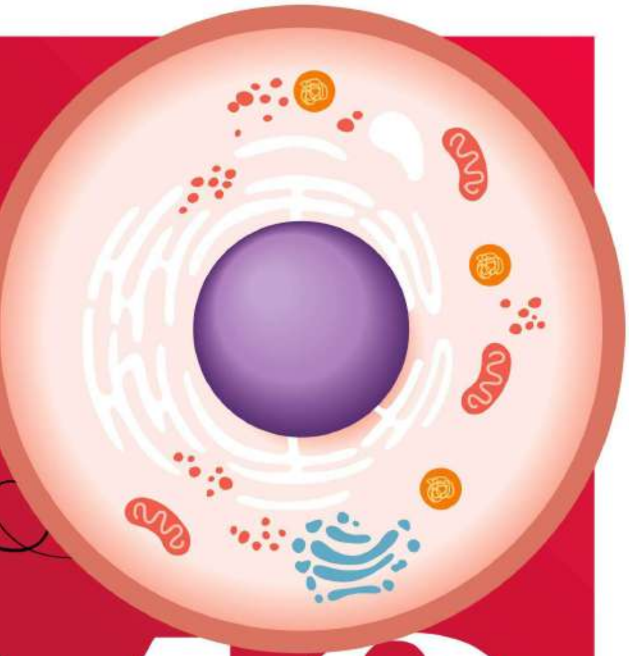
IF EARTH WERE A METRE WIDE, A MARBLE WOULD BE ONE NANOMETRE

2.2 NANOMETRES

Over 25,000 strands of DNA could fit onto a human hair

ONE ATOM

The thickness of the world's sharpest needle



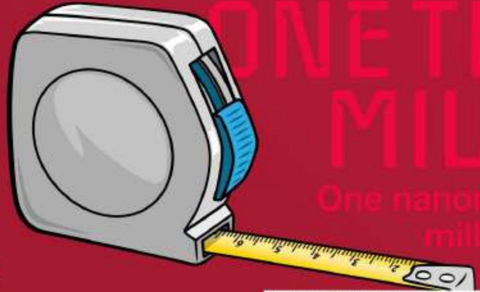
42 MILLION

Proteins inside a human cell number in the millions

100,000

A sheet of paper is thousands of times thicker than a nanoparticle

THE EARLIEST NANOPARTICLES DECORATED CERAMICS AND GLASS



ONE THOUSAND-MILLIONTH

One nanometre is one thousand-millionth of a metre

NANOSCALE RANGES FROM 1 TO 100 NANOMETRES

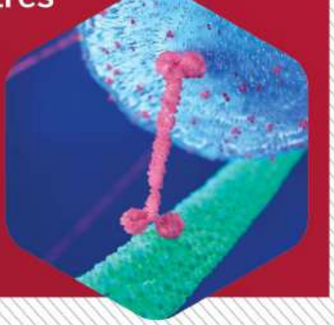
0
1
2
3
4
5
6
7
8
9
inch

25,400,000

The number of nanometres in an inch

100 NANOMETRES

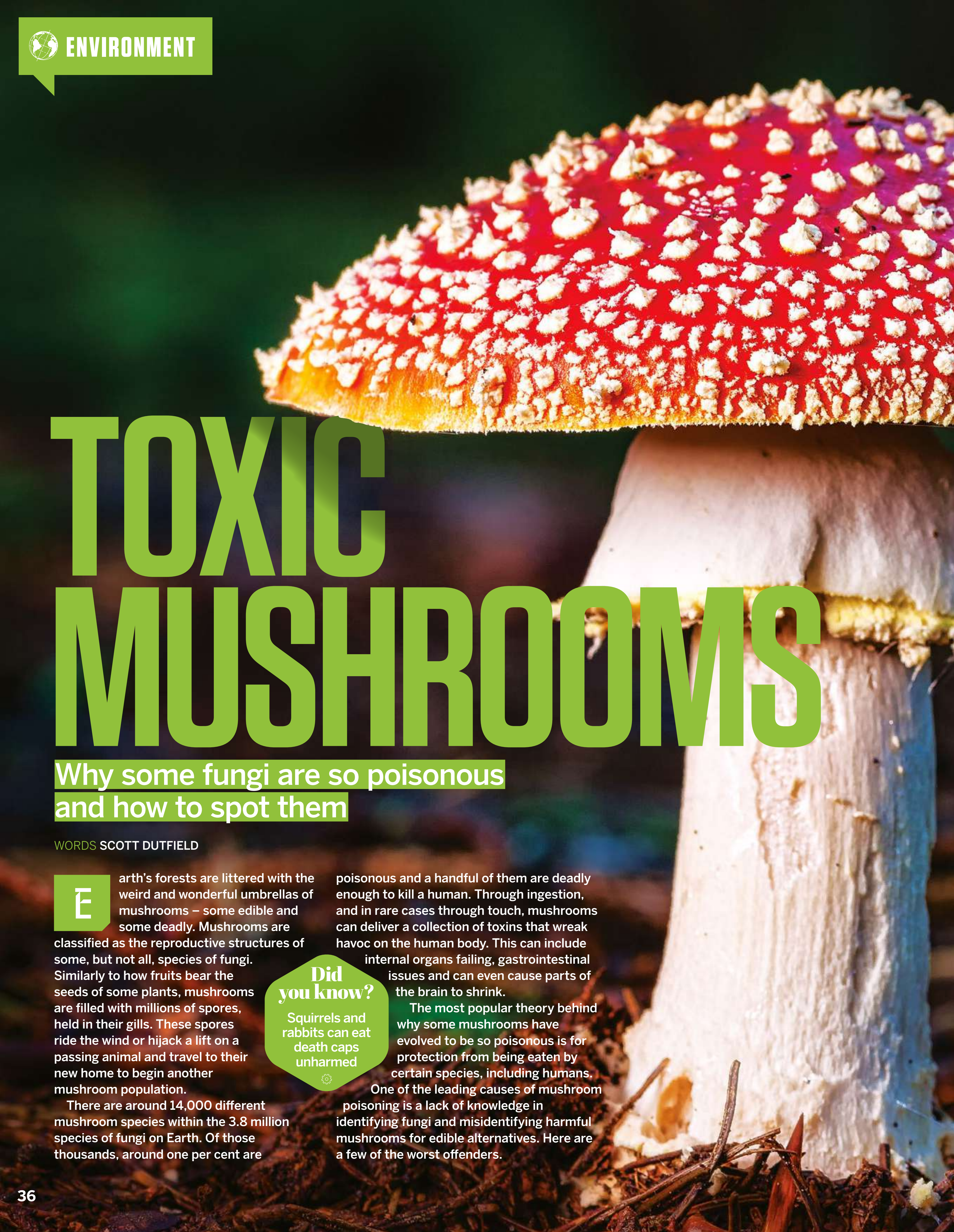
A SARS-Cov-2 coronavirus particle is nearly 50 times wider than DNA



EIGHT NANOMETRES

The size of a natural molecular motor

© Getty



TOXIC MUSHROOMS

Why some fungi are so poisonous and how to spot them

WORDS **SCOTT DUTFIELD**

Earth's forests are littered with the weird and wonderful umbrellas of mushrooms – some edible and some deadly. Mushrooms are classified as the reproductive structures of some, but not all, species of fungi. Similarly to how fruits bear the seeds of some plants, mushrooms are filled with millions of spores, held in their gills. These spores ride the wind or hijack a lift on a passing animal and travel to their new home to begin another mushroom population.

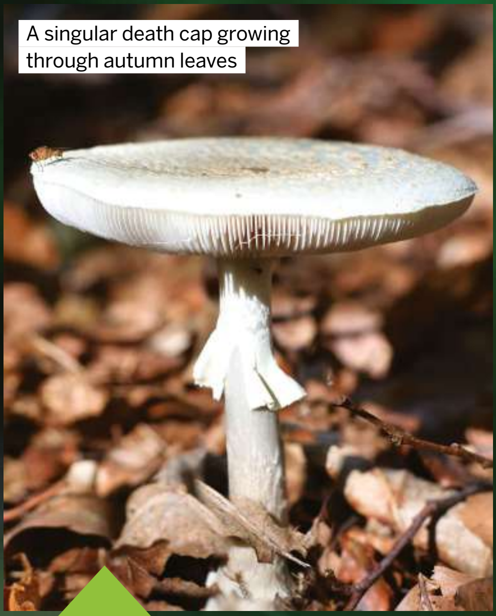
There are around 14,000 different mushroom species within the 3.8 million species of fungi on Earth. Of those thousands, around one per cent are poisonous and a handful of them are deadly enough to kill a human. Through ingestion, and in rare cases through touch, mushrooms can deliver a collection of toxins that wreak havoc on the human body. This can include internal organs failing, gastrointestinal issues and can even cause parts of the brain to shrink.

The most popular theory behind why some mushrooms have evolved to be so poisonous is for protection from being eaten by certain species, including humans. One of the leading causes of mushroom poisoning is a lack of knowledge in identifying fungi and misidentifying harmful mushrooms for edible alternatives. Here are a few of the worst offenders.

Did you know?

Squirrels and rabbits can eat death caps unharmed

DID YOU KNOW? Studies have found that there are thousands of different fungi species in a single soil sample


A singular death cap growing through autumn leaves

POISON FIRE CORAL

PODOSTROMA CORNU-DAMAE

Poison fire coral looks like it belongs under the sea rather than in the woods, with its reddish finger-like protrusions emerging from the soil. Nevertheless, this potent fungus can be found on tree roots across Asia, including Japan, Korea and Java. Unlike many other deadly mushrooms that are poisonous when eaten, the toxins in poison fire coral can be absorbed straight into the skin. Touching the fungus can cause inflammation and dermatitis, a skin irritation. When eaten, toxins in these mushrooms called trichothecene mycotoxins can cause the skin to peel, hair loss and even cause shrinkage of the cerebellum – the portion of the brain involved in movement and speech.

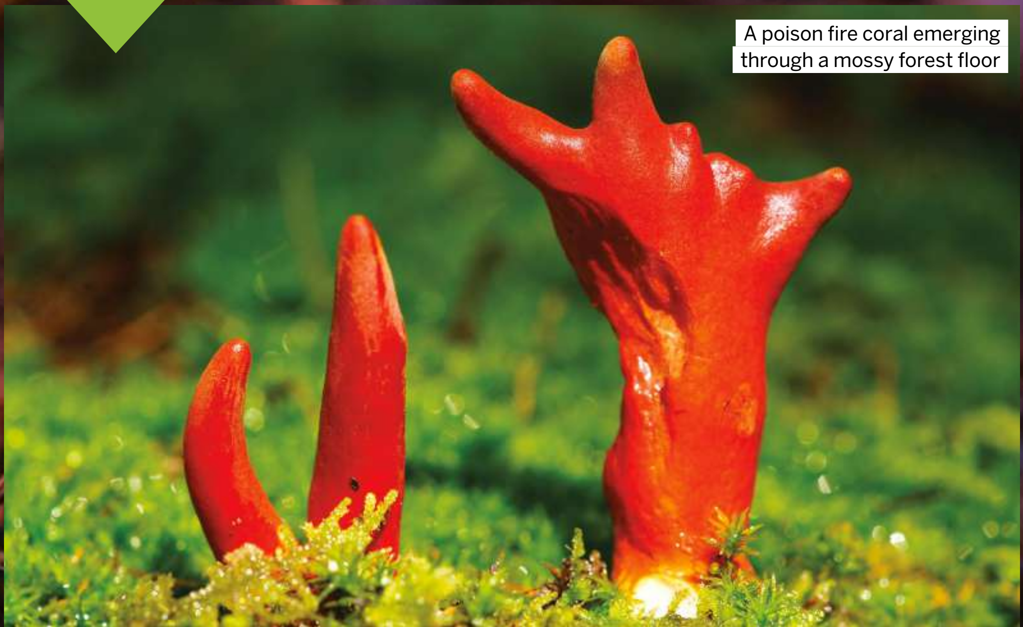
Unfortunately, these mushrooms have mysteriously found their way from Asia to Queensland, Australia. Although scientists are unsure as to how and when the mushroom migrated, some researchers have suggested its spores may have made the journey down under thousands of years ago.

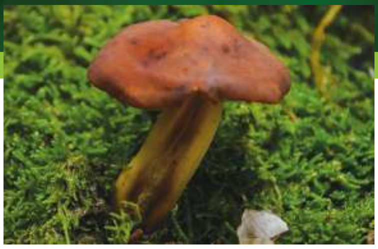
DEATH CAP

AMANITA PHALLOIDES

The most poisonous mushroom on Earth is the death cap, accounting for 90 per cent of all deaths caused by fungi. Death caps are common throughout forests in the UK, Ireland and Europe and often grow near oak and beech trees. However, they can be found on almost every continent.

These deadly mushrooms don't look particularly threatening or too dissimilar from grocery-variety mushrooms. However, they contain a highly potent toxin that is strong enough to kill a person. Eating just half of the mushroom cap can be fatal. The initial symptoms of death cap poisoning include diarrhoea and vomiting, which can cause dehydration if fluids are not maintained. The amatoxins – a group of toxins found in other mushroom species – within the death cap affect the function of the human body's liver cells, called hepatic cells. The toxins are eliminated from the body via the kidneys and urine, but without swift medical intervention the hepatic cells will die and the liver will fail around two to three days after ingestion.

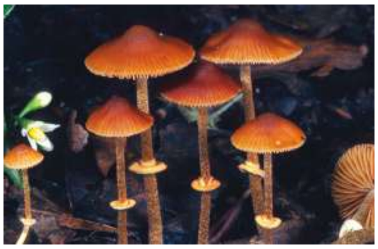

A poison fire coral emerging through a mossy forest floor


A brown deadly webcap growing in a forest in Croatia

DEADLY WEBCAP

CORTINARIUS RUBELLUS

Webcaps are among the largest known genera of fungi on Earth. Around 2,000 to 3,000 species have been identified. However, this deadly webcap is rarely found outside of northern Europe. Symptoms of eating a deadly webcap include vomiting, diarrhoea, headaches and ultimately kidney failure. These mushrooms have a potent toxin called orellanine. When ingested, orellanine produces oxygen radicals that damage kidney cells and can cause renal failure. The last known case of webcap poisoning in the UK was in 1979. The species has been confused with the edible chanterelle (*Cantharellus cibarius*) mushroom.


A group of fool's conecap mushrooms, found in Lower Rhine, Germany

FOOL'S CONECAP

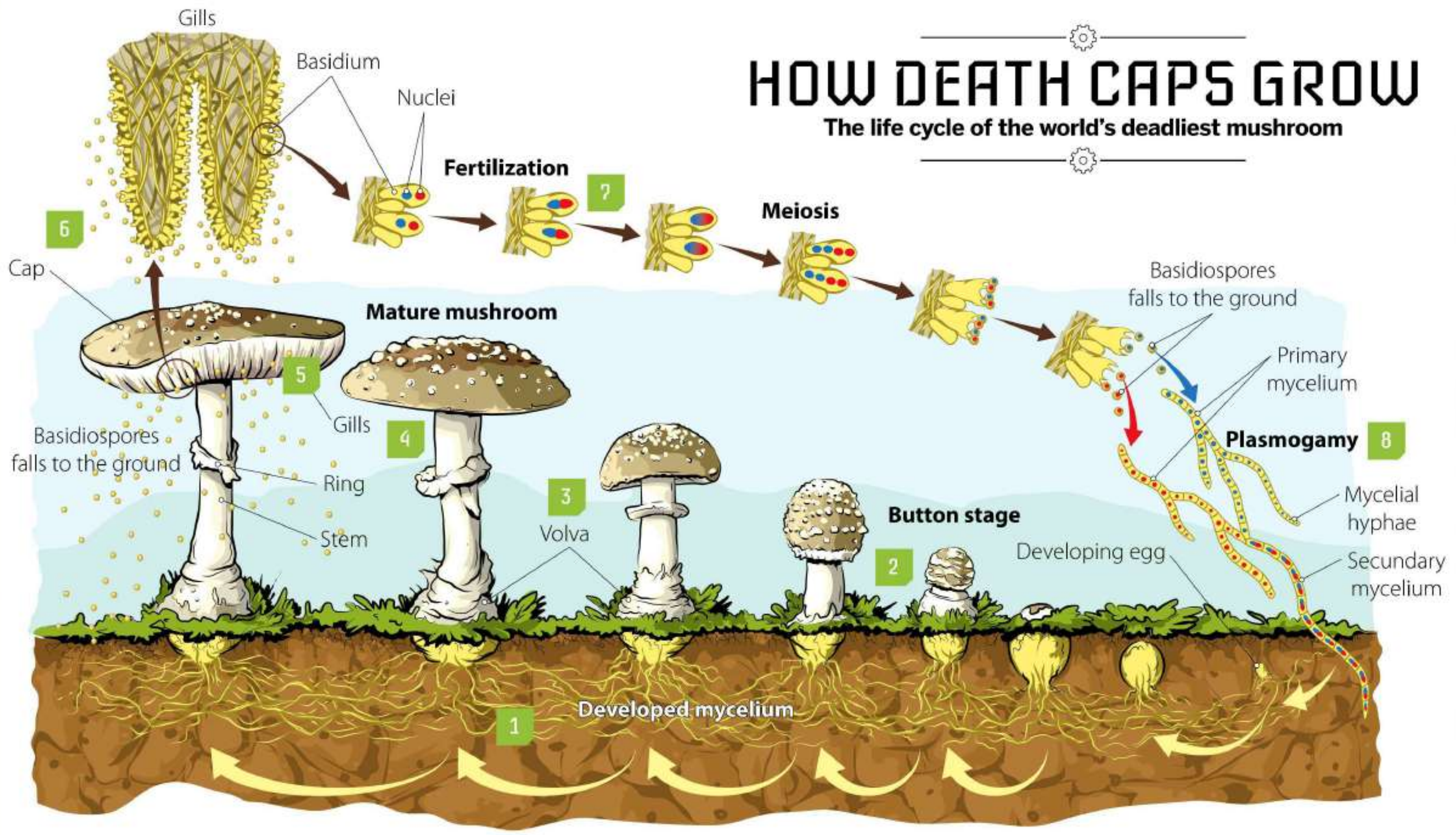
CONOCYBE FILARIS

This is a widely distributed lawn mushroom that can be found in Europe, Asia and North America, particularly in the Pacific Northwest region of the US. Amatoxins are this mushroom's poison of choice. The amatoxins found in a fool's conecap are made up of nine different types of toxins that together prevent vital proteins from being synthesised in liver and kidney cells, which can be fatal. Those that ingest it develop gastrointestinal symptoms within 24 hours. Symptoms can be overlooked as food poisoning or stomach flu. This mushroom is often mistaken for hallucinogenic mushrooms such as psilocybin mushrooms. However, unlike psilocybin mushrooms, their cone-shaped caps will eventually open out into an umbrella.

© Alamy / Getty

HOW DEATH CAPS GROW

The life cycle of the world's deadliest mushroom


Gills
Basidium
Nuclei
Fertilization
7
Meiosis
6
Cap
Basidiospores falls to the ground
Primary mycelium
Mature mushroom
5
Gills
4
Plasmogamy
8
Basidiospores falls to the ground
Ring
Stem
3
Volva
Button stage
Mycelial hyphae
Developing egg
Secundary mycelium
2
Developed mycelium
1

1 MYCELIUM
These are root-like fungal structures from which mushrooms grow. They break down nutrients in the soil for food.

2 BUTTON STAGE
The first mushroom structure to appear above ground. It's odourless, unlike its sweet-smelling adult form.

3 VOLVA
The universal veil – a layer of tissue that once surrounded the baby mushroom – forms a bag at the base of the adult mushroom called the volva.

4 MATURE MUSHROOM
A mature death cap mushroom will measure around 15 centimetres tall and have a domed white cap with a white stem.

5 GILLS
In the gills of the mushroom are structures called basidia that bear reproductive spores.

6 SPORES
Billions of spores are released from the gills, carrying the genetic information of the mushroom away.

7 GERMINATION
Just like reproductive cells in humans, called gametes, spore cells undergo meiosis, whereby they divide and multiply and form long structures called primary mycelium.

8 PLASMOGAMY
At this point, two primary mycelium fuse together to make one final mycelium that develops and grows into a single mushroom.

Did you know?
Some mushroom species are bioluminescent

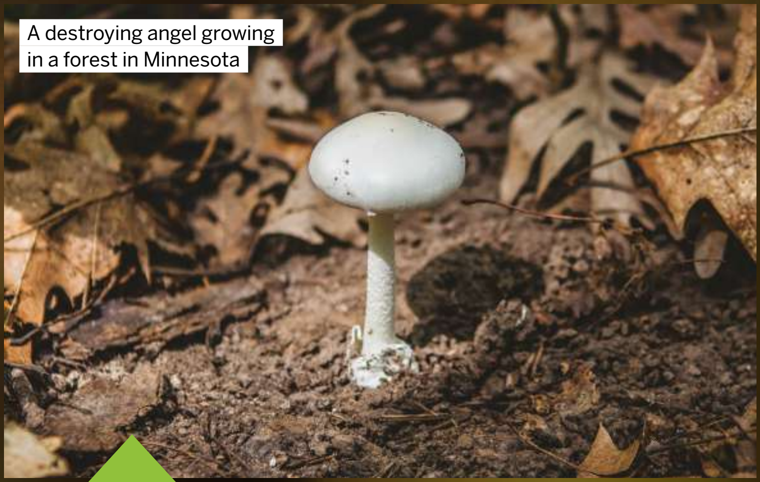
AUTUMN SKULLCAP

GALERINA MARGINATA

Also known as deadly galerina or funeral bell, these brown mushrooms pack a punch in the poison department. Similar to the death cap and destroying angel, autumn skullcaps are filled with amatoxins that target the liver and cause hepatic cell failure. Although the concentrations of these toxins are lower than other deadly species, they can still cause vomiting and ultimately liver failure around 72 hours after ingestion. Amatoxins are also heat-stable, so cooking these mushrooms doesn't remove or break the toxins down. These fungi like to grow on decaying hardwood and softwood, which appear to contribute to the number of different amatoxins within the mushroom along with its genetic make-up and other environmental factors.

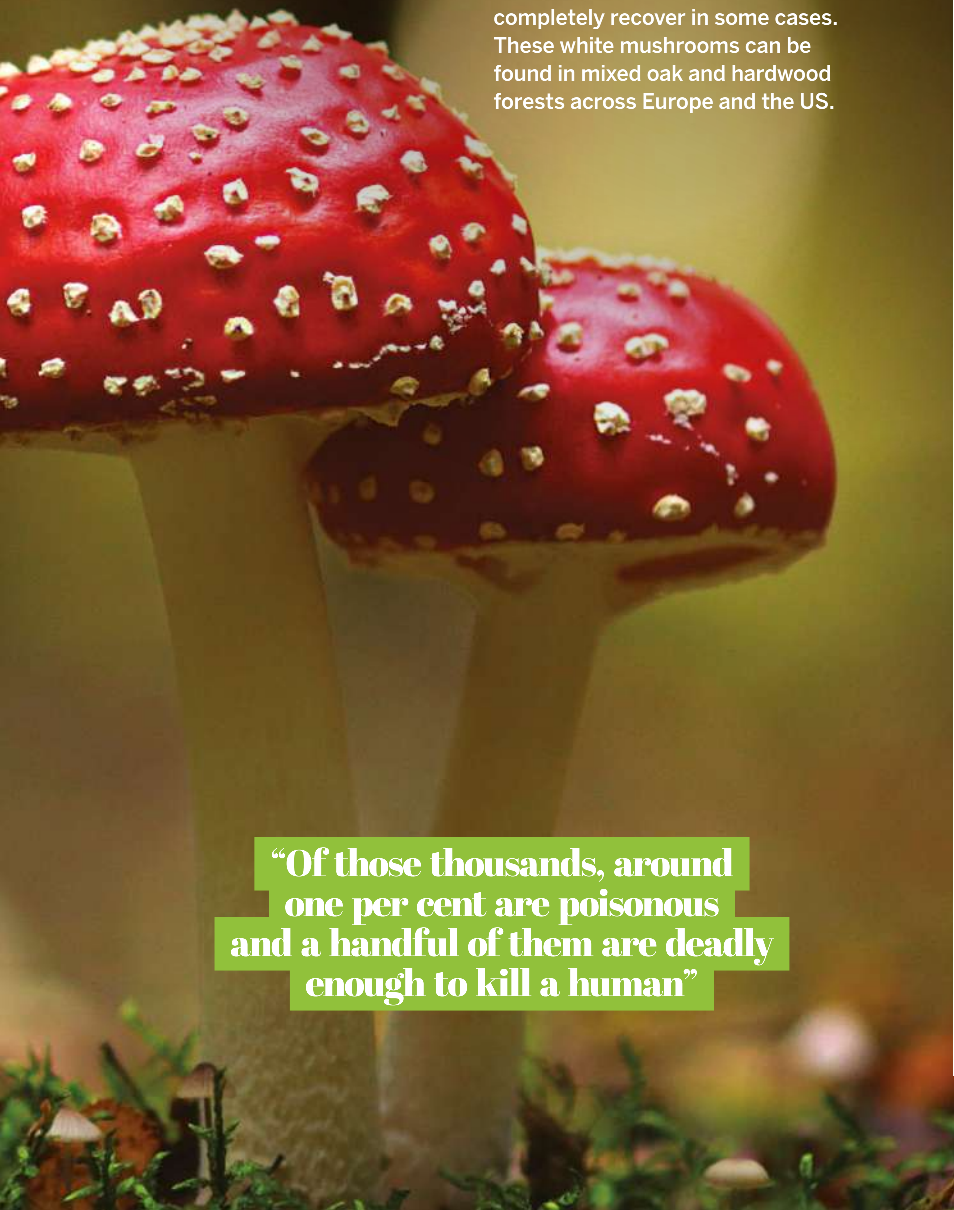
Poisonous *Galerina marginata* growing in a floodplain forest

DID YOU KNOW? The lethal dose of death cap poison is 0.1 milligrams per kilogram of human weight


A destroying angel growing in a forest in Minnesota

DESTROYING ANGEL *AMANITA VIROSA*

As angelic as this mushroom may appear, its poisonous biology makes it devilishly dangerous. Closely related to the death cap, the destroying angel, also known as the death angel, contains a cell necrosis-inducing amatoxin. Research has found that these toxins can induce apoptosis, the process of programmed cell death. Like other mushrooms containing amatoxins, poisoning symptoms begin as gastrointestinal irritation and later develop into more serious damage to the kidney and liver. Unlike its more toxic cousin the death cap, ingesting destroying angels isn't always a death sentence, and the human liver can completely recover in some cases. These white mushrooms can be found in mixed oak and hardwood forests across Europe and the US.



> "Of those thousands, around one per cent are poisonous and a handful of them are deadly enough to kill a human"

STAYING SAFE AROUND MUSHROOMS

David Winnard is a foraging expert and founder of Discover the Wild, a UK-based natural history company that offers foraging and species identification services. Winnard is a renowned naturalist in the UK and has worked with many conservation organisations and local councils through his career

How do you spot a poisonous mushroom? Are there distinguishing features people should look out for?
There's no clear way of saying if it has this, it's edible; if it has that, it's poisonous. It's not as simple as that. What we have are families which are generally considered edible which have poisonous members. Similarly, you get very poisonous family groups that happen to have some edible ones. Learn edibles that have no poisonous lookalikes. In parts of Europe, this is what's done. Learn different edible species, stick to those and don't deviate. For example, porcini mushrooms don't have anything that looks like them that is going to kill you. With foraging, identify the edible ones and ignore everything else to eliminate all the poisonous ones.

If you see a death cap under stress or in dry conditions it can look similar to blusher [*Amanita rubescens*], and they grow in the same habitat. If you're going along with a basket and not really thinking about what you're doing, a death cap can end up in your basket very easily. I tell people just don't eat anything from the *Amanita* family, even if it's edible. There's no mushroom I've tried that is worth dying for.

Why is the death cap so dangerous?
Death cap is a particularly worrying one because it has no mechanism for people to stop eating it. With a lot of mushrooms, they're bitter or foul-tasting or they smell bad. Whatever it is, your body reacts and says spit it out. Death cap doesn't have that. It smells sickly sweet – like honey in some cases – you can almost smell them before you see them.

What advice do you have for anyone thinking of foraging wild mushrooms in the UK?
Understand your limits about what you do and don't know. Be brave enough to say you don't know. If you are 99.999 per cent sure, do not eat it. You need to be 100 per cent certain. You also need to have the discipline to take the whole specimen home and confirm what you think it is with good reputable field guides, not apps. I've field-tested quite a few [mushroom identification] apps, and I think this is where more recent poisonings are probably coming from because people are relying on pointing their phone at a mushroom and seeing what it is. These apps are so far away from being reliable for mushrooms. For indoor house plants they're great, because plants are very formulaic [in their appearance] – mushrooms are not.

© Getty / Shutterstock / David Winnard

GROWING GLACIERS

How these vast ice flows form, grow and why they vanish

WORDS **SCOTT DUTFIELD**

Glaciers are made up of compacted snow, rocks and sediment that over millennia has formed sheets of dense ice on land. Every one of the 98,000 glaciers that remain on Earth are the frozen leftovers of the last ice age, which occurred during the Pleistocene epoch between 2.6 million and 11,700 years ago. There are many different types of glaciers on Earth, such as continental ice sheets and alpine glaciers that descend from mountaintops and shape the rocks they pass through.

Over the course of the last ice age, new layers of ice formed and compressed the previous layers, creating ever-growing glaciers. During the formation of a glacier, the compressed snow will transform into firn, a compressed and crystalline form of ice that is around two-thirds as dense as water. At this point, firn is held under so much pressure that it reaches a density of 917 kilograms per cubic metre and becomes pure glacier ice – for comparison, fresh snow has a density of 50 to 70 kilograms per cubic metre. Firn's transformation takes up to 300 years.

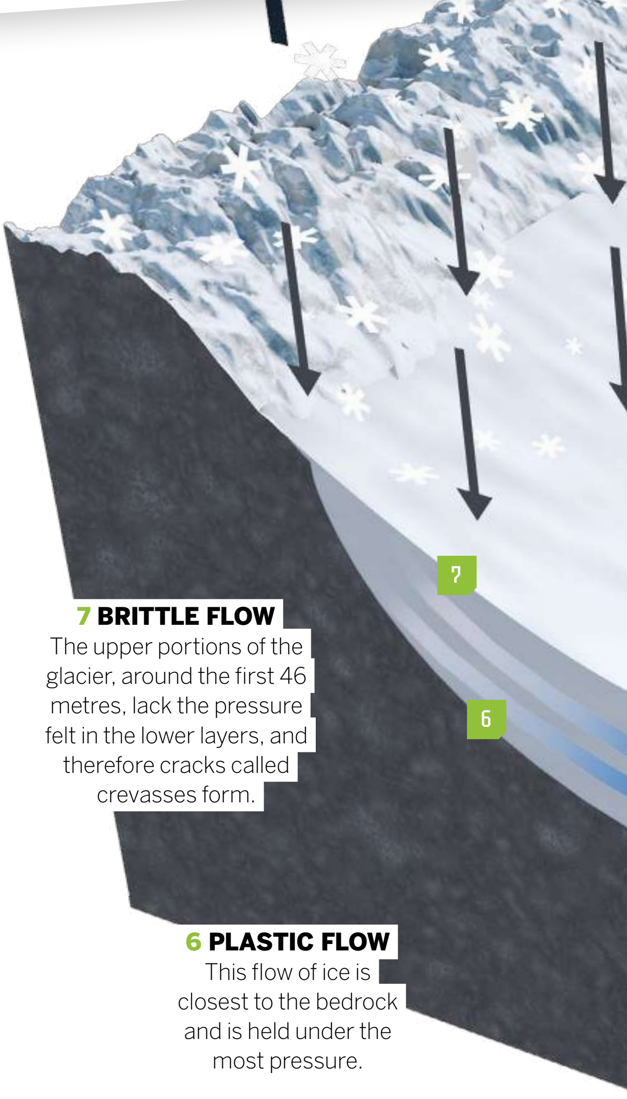
These icy giants are not static slabs, transporting enormous volumes of water across the land while sculpting and carving out their landscape. Due to their size and mass – some glaciers can carry tens of millions of tonnes of ice – gravity causes ice to move slowly. While on the move, glacier ice can erode stone and rock to create valleys and lakes. They can also act as a taxi for falling boulders called glacial erratics, which are deposited when the ice melts. They can end up less than a mile from their parent rock or farther than 500 miles from where it was collected.

Glaciers are maintained through an equilibrium of new snow and ice formation and the destruction and removal of existing ice, known as a glacial budget. When this balance is thrown out of whack, it can lead to a glacier retreating and ultimately completely melting away. If the amount of snow accumulating on a glacier exceeds the amount of ice that melts, then glaciers will advance, and in some cases surge. In 1986, the Hubbard Glacier in Alaska surged across the mouth of Russell Fjord at a rate of ten metres per day.

Did you know?

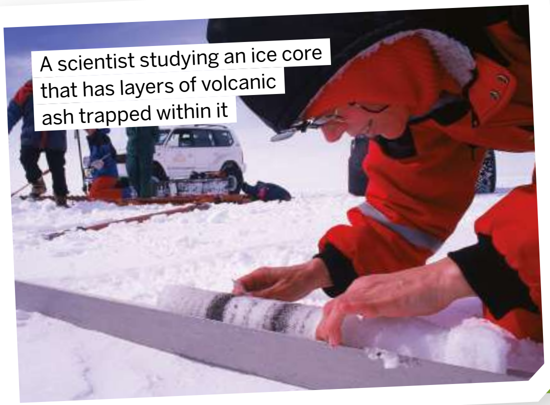
Around two per cent of all water on Earth is frozen in glaciers

An aerial view of Sondrestrom glacier in Greenland



7 BRITTLE FLOW
The upper portions of the glacier, around the first 46 metres, lack the pressure felt in the lower layers, and therefore cracks called crevasses form.

6 PLASTIC FLOW
This flow of ice is closest to the bedrock and is held under the most pressure.



A scientist studying an ice core that has layers of volcanic ash trapped within it

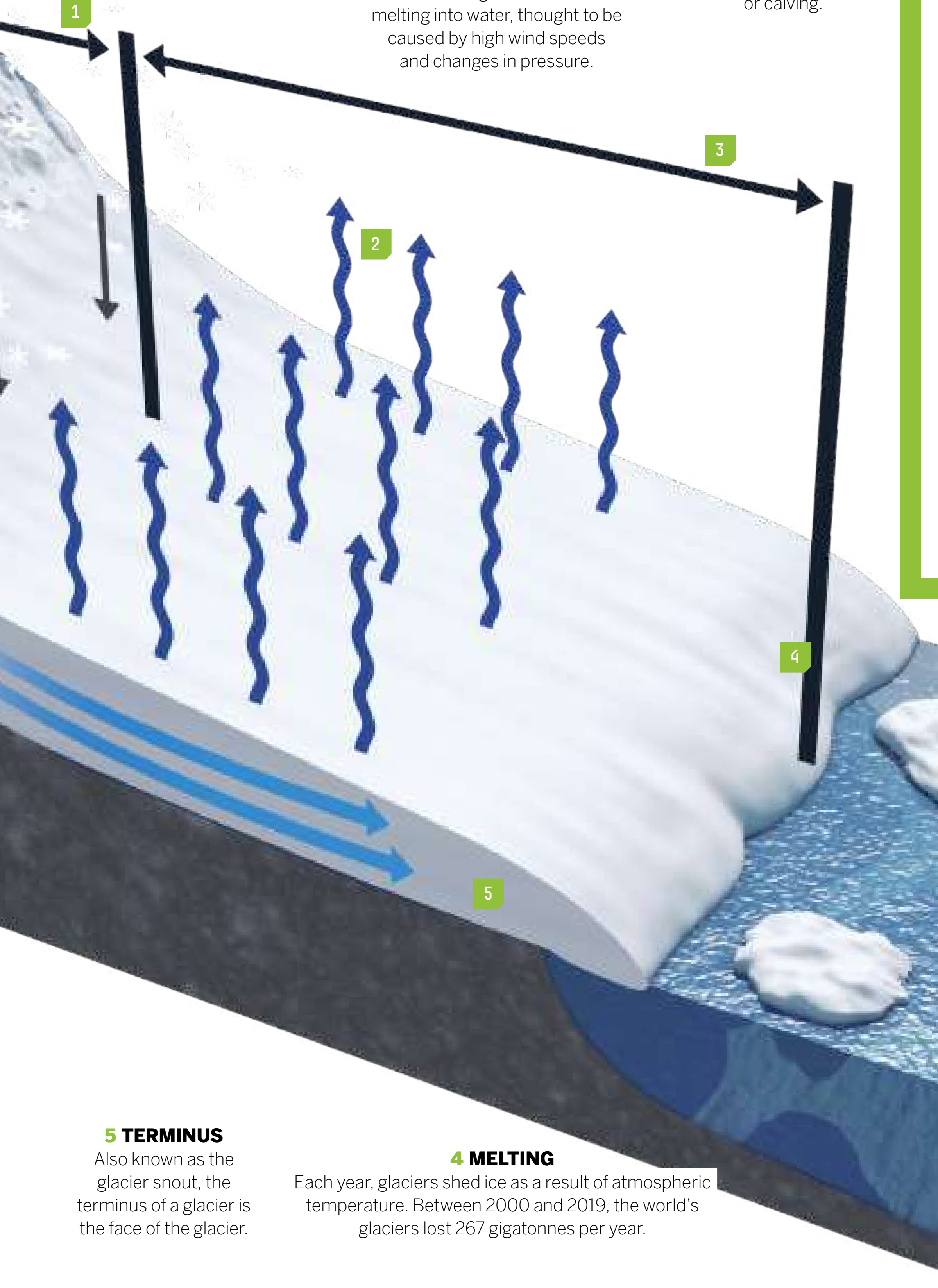
TIME CAPSULES

Glaciers are a useful tool used by scientists to study Earth's past, present and future. As they form, ice layers trap bubbles of air that contain a whole host of information about what Earth's atmosphere would have been like at that time. Paleoclimatologists can drill thousands of metres into the ice and collect tubular ice samples called ice cores. The cores are then subjected to several physical and chemical tests to create a timeline of environmental changes as you move up through the layers in the ice core. The data collected from these samples can include concentrations of greenhouse gases, levels of precipitation, volcanic activity and even wind patterns – all from thousands of years ago.

DID YOU KNOW? Less than 32 per cent of all land and 30 per cent of the oceans were covered in ice during the last ice age

GLACIER ANATOMY

How the glacial budget maintains a frozen balance within these icy giants



1 ACCUMULATION ZONE
This is the zone where ice is gained through snowfall, found at the highest elevations.

2 SUBLIMATION
This is the primary mass loss of glaciers. Ice transitions from a solid state into a gas without first melting into water, thought to be caused by high wind speeds and changes in pressure.

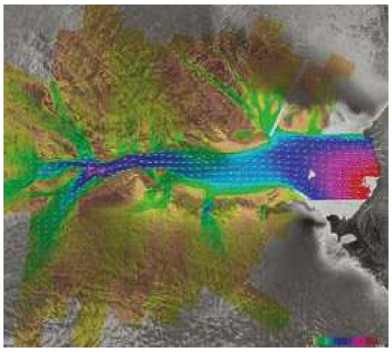
3 ABLATION ZONE
This is the zone where ice is lost through melting, sublimation or calving.

4 MELTING
Each year, glaciers shed ice as a result of atmospheric temperature. Between 2000 and 2019, the world's glaciers lost 267 gigatonnes per year.

5 TERMINUS
Also known as the glacier snout, the terminus of a glacier is the face of the glacier.

RECORD BREAKER

It's not surprising that the largest glacier on Earth can be found in Antarctica. It's called the Lambert glacier, named after Bruce P. Lambert, former director of national mapping at the Australian Department of National Development. The glacier runs 250 miles long and spans 60 miles wide. It's also one of the fastest moving glaciers in the world; most of the glacier travels between 400 and 800 metres per year. At the point where the ice leaves the Antarctic ice sheet and enters the adjacent Amery Ice Shelf it moves even quicker, at around 1,000 to 1,200 metres per year.



A coloured satellite image of Lambert glacier. Red indicates the fastest moving ice and yellow and green the slowest

AR zone SCAN HERE

© Alamy / Getty / Canadian Space Agency/NASA/Ohio State University, Jet Propulsion Laboratory, Alaska SAR facility / Illustration by Adrian Mann

THE AMAZING ANGLERFISH'S WEIRD LIFE

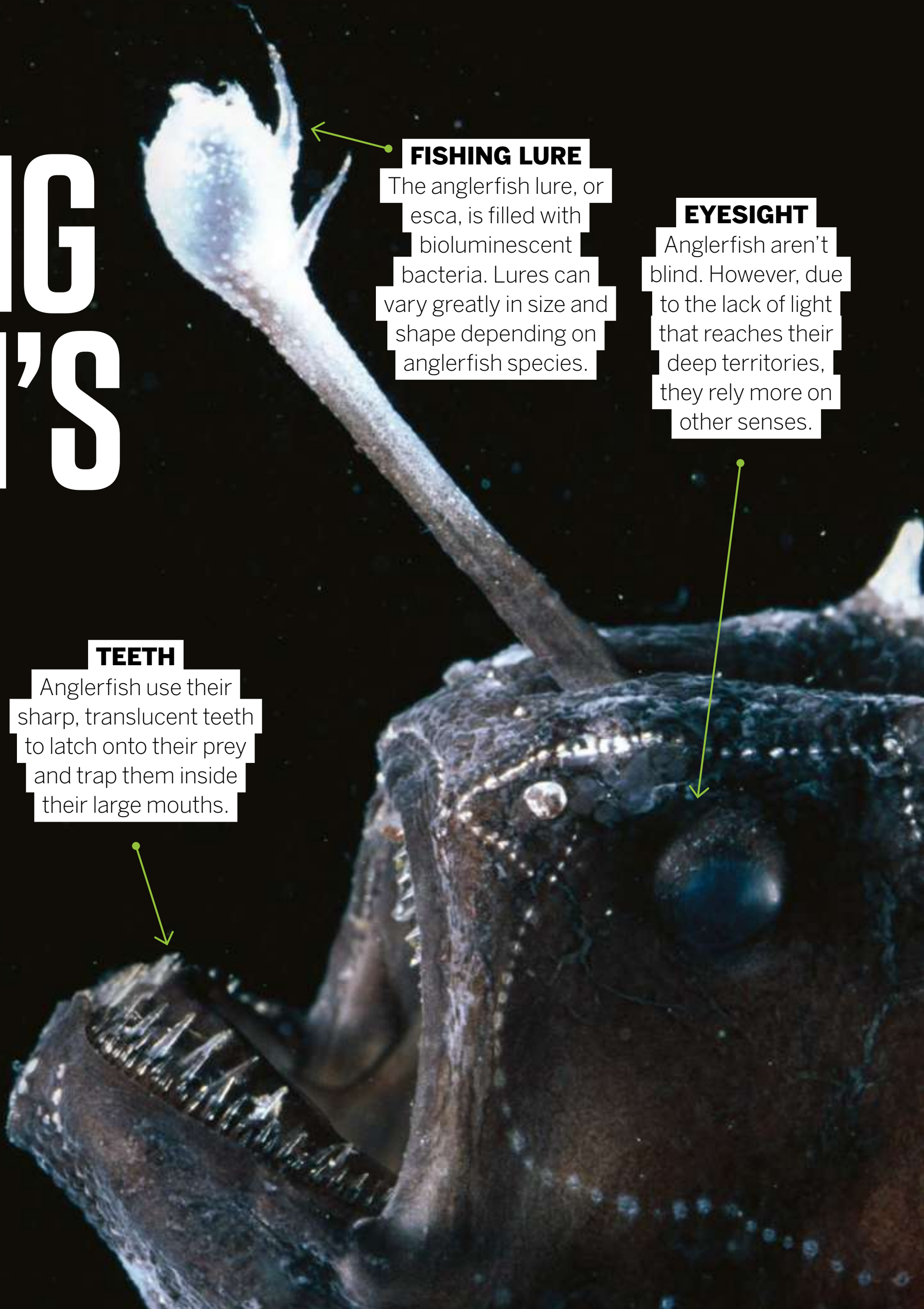
Deep below the ocean's surface are deadly predators that lure their prey with light

WORDS **SCOTT DUTFIELD**

Anglerfish are one of the most frightening creatures in the ocean. If their bucket-sized mouths bearing razor-sharp teeth, tiny frosted eyes and spiky fins weren't scary enough, add the ability to lure prey with glowing head lanterns and anglerfish become the stuff of nightmares. Thankfully, these fish aren't usually found anywhere where humans can cross their path. Anglerfish enjoy the silence and darkness of the ocean's twilight zone and have been found as deep as 2,000 metres below the surface.

There are more than 200 anglerfish species roaming the depths of the oceans around the world. Each species varies in size and shape, from only a few centimetres in length to bodies over a metre long and weighing up to 50 kilograms. As ambush predators, these fish entice their prey to swim within reach of their massive mouths using a bioluminescent lure, known as an esca, that hangs in front of their face. The lure is like bait at the end of a fishing rod – hence the name anglerfish. Once the prey has fallen victim to the allure of the glowing esca, it's quickly met with the mouth of the anglerfish.

Unlike other bioluminescent marine life, anglerfish don't produce the luminance themselves and have instead recruited a host of glowing bacteria. These are called photobacteria and sit within the anglerfish's lure. The relationship between the fish and bacteria is a mutualistic one. The bacteria get safe passage around the ocean, collecting nutrients along the way, and the anglerfish gets a free fishing lure. However, there is one mystery about these bacteria that still has scientists scratching their heads: where did they come from? Some research has suggested that these glowing bacteria are just floating around the ocean awaiting an anglerfish pickup, while others have proposed that mother anglerfish might pass on their bacteria to juvenile anglerfish somehow.



FISHING LURE
The anglerfish lure, or esca, is filled with bioluminescent bacteria. Lures can vary greatly in size and shape depending on anglerfish species.

EYESIGHT
Anglerfish aren't blind. However, due to the lack of light that reaches their deep territories, they rely more on other senses.

TEETH
Anglerfish use their sharp, translucent teeth to latch onto their prey and trap them inside their large mouths.

JAW
Their enormous jaws allow them to eat prey up to twice their own size.

A deep-sea anglerfish known as the black seadevil

Did you know?
Around 1,500 species of fish can luminesce

DID YOU KNOW? The smallest sexually mature vertebrate was a 6.2-millimetre anglerfish male attached to a 46-millimetre female

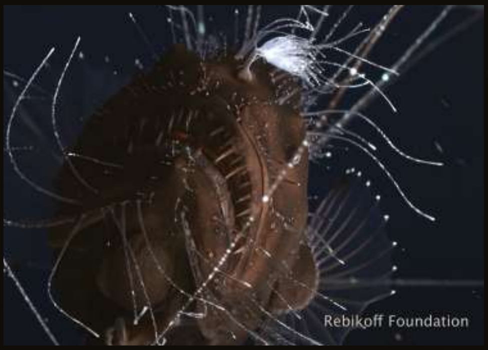
SEA MONSTERS FROM THE DEEP

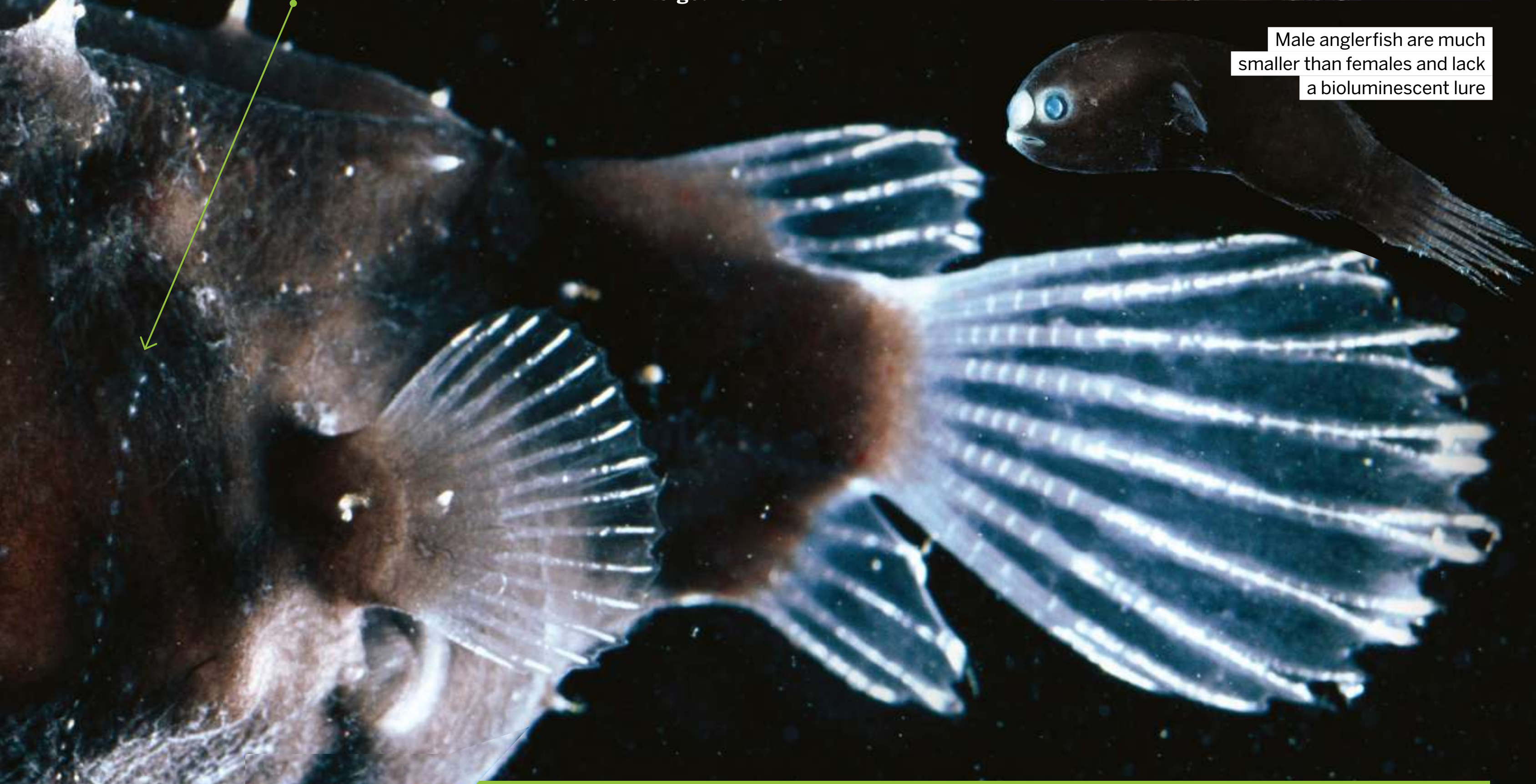
How these deadly predators hunt and survive thousands of metres below the surface

THE FIRST FOOTAGE OF A MATING PAIR

There have been a handful of dead anglerfish specimens that have allowed scientists to discover the sexual parasitism of these fish, but a living, mating pair were recorded for the first time in 2018 by researchers at the Rebikoff-Niggeler Foundation, a deep-sea research organisation. In this video, taken by researchers in the LULA 1000 submersible, a female fanfin seadevil slowly drifts through the water extending bioluminescent whisker-like fins. It remains unclear as to why she has these long structures, but it's been suggested that it may relate to warding off predators or further attracting prey. On the underside of the female is what remains of the tiny male, which has now merged with her.

SCAN THE QR CODE TO WATCH


Rebikoff Foundation



SENSORY SPOTS

Due to their poor eyesight, especially in pitch-black waters, anglerfish use a series of white sensory spots dotted around their bodies to detect movement in the water.

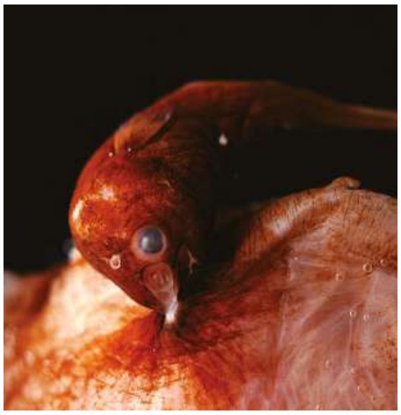
Male anglerfish are much smaller than females and lack a bioluminescent lure

FEEDING

Living in such harsh and sparsely populated environments, anglerfish pretty much eat whatever prey that comes their way, including other fish, squids and crustaceans.

PARASITIC PARTNER

In the depths of the ocean, the lack of light can make it hard to find a mate. For anglerfish, when a male and female finally cross paths they not only mate for life, they physically become one. Once a free-swimming male anglerfish bumps into a female, he latches onto her with a set of sharp teeth. Over time, the two begin to fuse. The male will eventually merge his skin, blood vessels and organs with the female until he is nothing more than a continual source of sperm to fertilise her eggs for reproduction. This form of reproduction is known as sexual parasitism and is the anglerfish's way of ensuring the next generation. Research has found that as little as one per cent of anglerfish males will encounter a female in their lifetime. This also isn't a monogamous relationship – females have been found to have more than six males on their bodies.

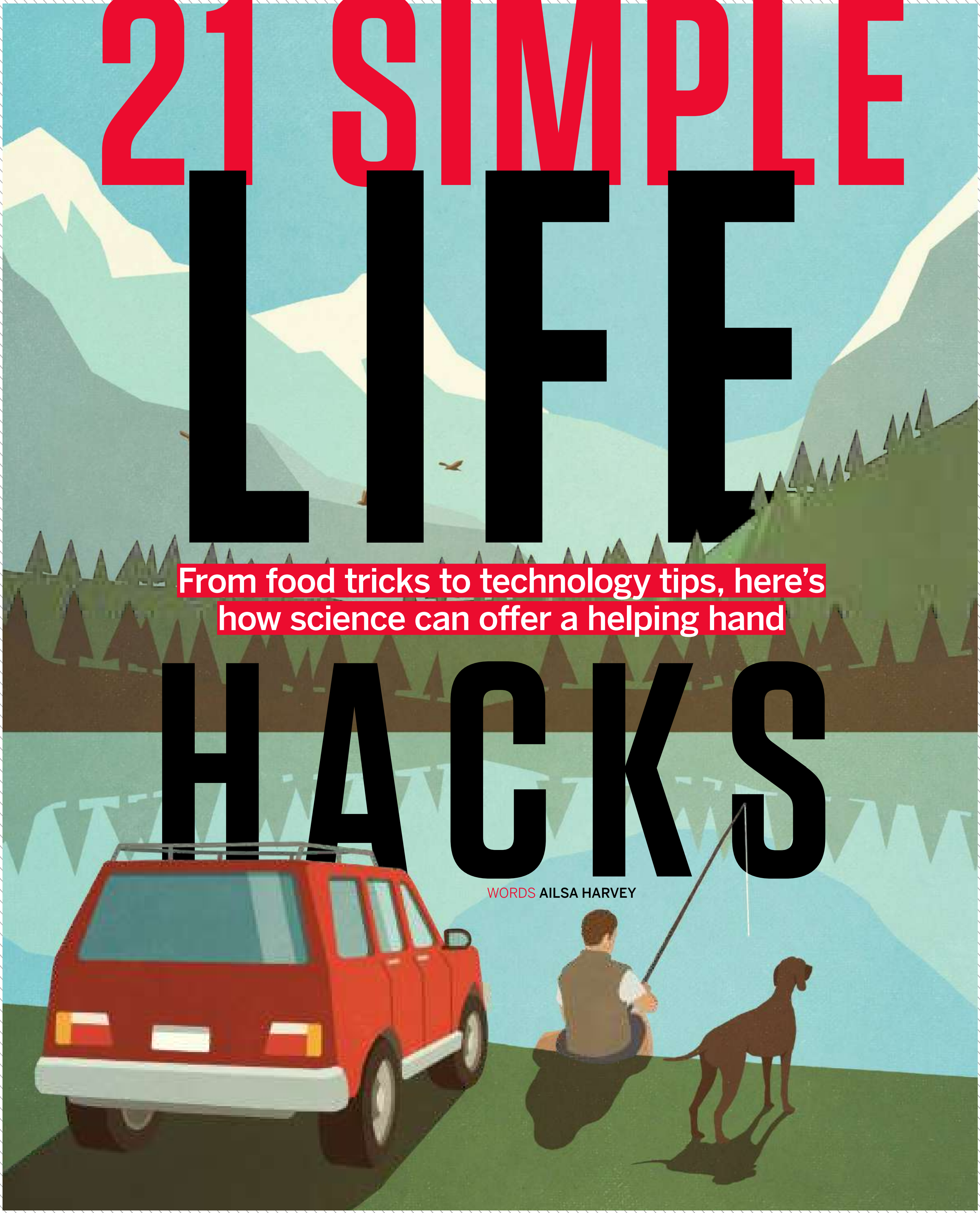

A male anglerfish merging with a female

© Alamy / Rebikoff Foundation

21 SIMPLE LIFE HACKS

From food tricks to technology tips, here's how science can offer a helping hand

WORDS AILSA HARVEY



DID YOU KNOW? The synthetic ingredients in chewing gum don't decompose

01

EASY EGG WHITES

Baking recipes often ask you to separate egg yolks from the whites, which can sometimes be easier said than done. An uncooked egg can be tricky to handle, with the slippery yolk hard to grab hold of. A common technique involves moving the yolk between the two halves of the broken shell and letting the whites run into a bowl, but this can be messy. To make this ordeal a simple process, all you need is an empty plastic water bottle. First, crack the entire egg, or eggs, into a shallow bowl. Take the open plastic bottle and squeeze it slightly to remove some of the air. Place the opening over the yolk you want to remove and release the bottle slightly to suck it up. The yolk will sit in the neck of the bottle, leaving the whites separated in the bowl.

The bottle can suck up the yolk

Did you know?

All of an egg's cholesterol is in the yolk

Chewing gum has an insoluble gum base

02

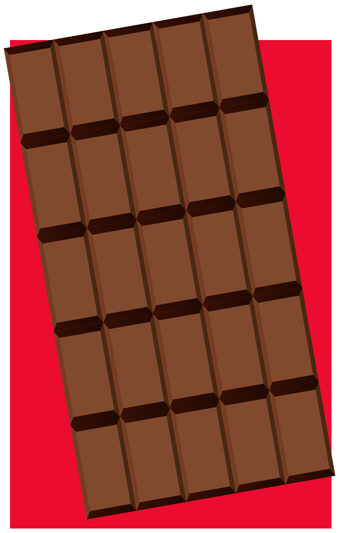
STICKY GUM CLEANUP

If you've ever accidentally stepped on or sat in chewing gum, you'll know the difficulty of trying to remove this rubbery mess. To reduce the stickiness and avoid pulling it apart string by string, apply an ice cube to harden the gum – then you can peel the gum away from your clothing with ease. If the gum is stuck in your hair, peanut butter works to reduce stickiness and the likelihood of needing a spontaneous haircut. To remove it, you need to completely cover the gum with peanut butter using your fingers or a spare toothbrush. The oils in the peanut butter make the base of the chewing gum stiffen and come loose from the hairs.

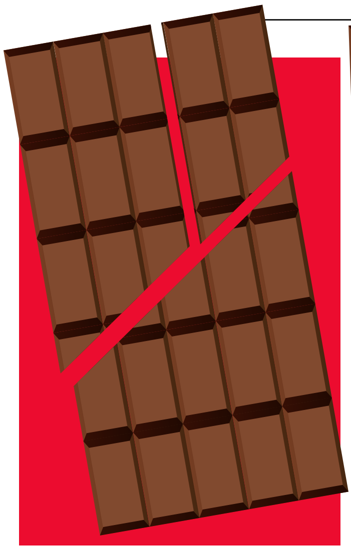
THE INFINITE CHOCOLATE TRICK

03

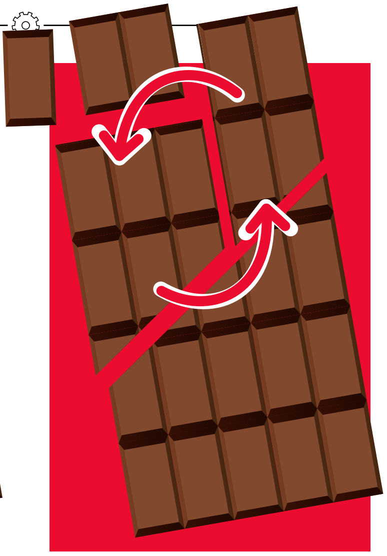
Take an extra piece of chocolate without anyone noticing



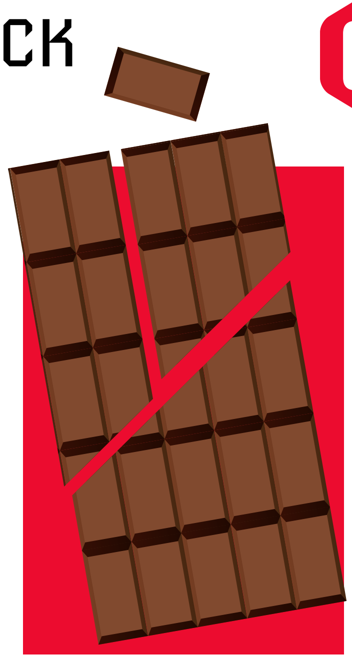
1 **SWEET TREAT** Take a chocolate bar that is made up of five by five blocks.



2 **CHOPPING UP** Make a diagonal cut from just below the second block from the bottom on the left side to just above the third block on the right side. Take the top piece and cut it vertically after the third block from the left on the top row.



3 **REARRANGE** Cut the top-left block off, and the two blocks to the right of it on the same row, but keep these two joined together. Move this single block and the pair away from the bar and swap around the two remaining pieces above the diagonal cut.



4 **BONUS SQUARE** Place the larger of the two small pieces back in the top-left corner of the chocolate bar. Now you have what looks like a five-by-five chocolate bar... and your spare piece.

> "Now you have a chocolate bar... and your spare piece"

© Getty

QUICK PHONE HACKS

04

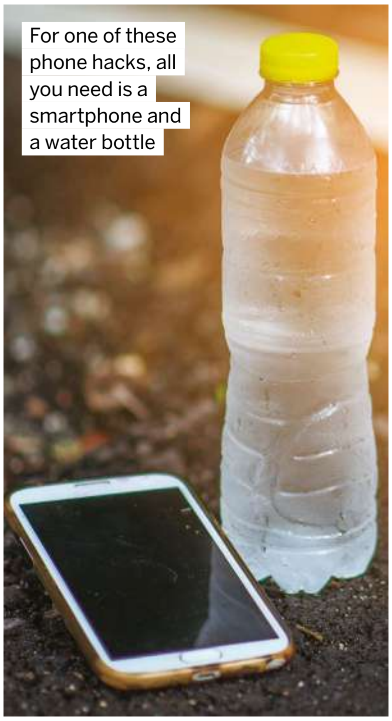
Using a few common items with a smartphone, you can maximise your phone's features. For example, if you ever find yourself with just a smartphone torch for light, you can turn this focused light into a lamp. To do this, you just need a full water bottle. Place your phone torch so that the light is shining upwards, and balance your water bottle – with any labels taken off – so that it covers the light. The water in the bottle bends the light in different directions to illuminate more of your surroundings at once.

05

You can also maximise your phone's speaker volume and audio quality. For the former, all you need to do is place the phone into a bowl or glass while playing music. While the music quality won't be exceptional, the volume will increase as the sound waves bounce against the bowl before being projected up and out.

06

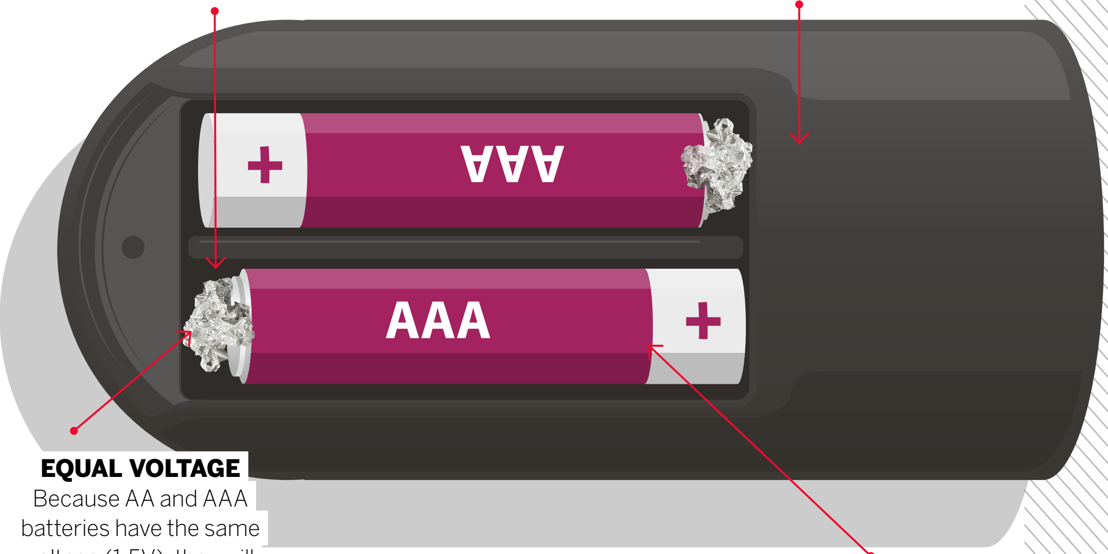
To improve the quality of audio in voice or video recordings and to block out background noise, cover the smartphone's microphone. At a concert, for example, this will block out the background noise and screams from the audience and focus more on the singer's sound.


For one of these phone hacks, all you need is a smartphone and a water bottle

07

TURN AAA BATTERIES INTO AA

Do you always have the wrong type of batteries lying around? Here's how to make your own AAs



FOLDING FOIL
Fold two pieces of foil into small ball shapes so that they fill the gaps. At the right size they will be in contact with the springs in the battery compartment and the end of the AAA batteries.

AA APPLIANCE
While AAA batteries can power AA appliances, the larger size of AA batteries allows them to deliver a greater current, so the correct battery should be used for long-term use.

EQUAL VOLTAGE
Because AA and AAA batteries have the same voltage (1.5V), they will work in the same appliances as long as the metal foil remains in contact with the battery terminal to pass the electric current.

SAFETY
Because AA and AAA batteries have a low voltage, they can be changed relatively safely. However, if you notice anything unusual you should remove the batteries and foil.

AAA BATTERY
AAA batteries are smaller than AA batteries. When they are placed in an AA battery compartment, significant gaps are left.

08

BATTERY BOUNCE TEST

For those who forget to throw away used batteries immediately, it can be impossible to know just by looking at them which batteries have been used and which are new. However, science can help you answer this question. When a conventional battery is unused, the molecules in its outer zinc layer are randomly arranged. This means if the battery is dropped, the molecules can move to absorb some of the kinetic energy and prevent it from bouncing too much. For used batteries, the zinc has been converted into zinc oxide and the molecules line up more uniformly. The kinetic energy is passed through the molecules and creates a recoil, pushing the battery back off the ground. If you ever need a hint as to which batteries have previously been used, dropping them from the same height could provide the answer. Those that bounce higher are likely to be used.

Batteries look the same from the outside whether they are new or completely depleted

Did you know?
3 billion batteries are bought in America each year

DID YOU KNOW? Polarised glasses can make objects appear darker, but their details clearer

COOL COOKING HACKS

09 IDENTIFY BAD EGGS

If you've had eggs in the fridge for a while and are unsure if they have gone off or not, simply put them in a bowl of cold water. If they sink and lie flat, they're good to eat. Bad eggs will float.

10 COOL DRINKS FASTER

If you need to make a drink cold in a short space of time, wrap a damp paper towel around it. The water in the paper towel will evaporate, cooling the bottle and its contents faster than the surrounding air would.

11 REDUCE COFFEE BITTERNESS

If you have a cup of coffee that tastes a bit too bitter for your liking, add a pinch of salt. When the salt dissolves, the sodium ions break off to block bitter molecules from your tongue.

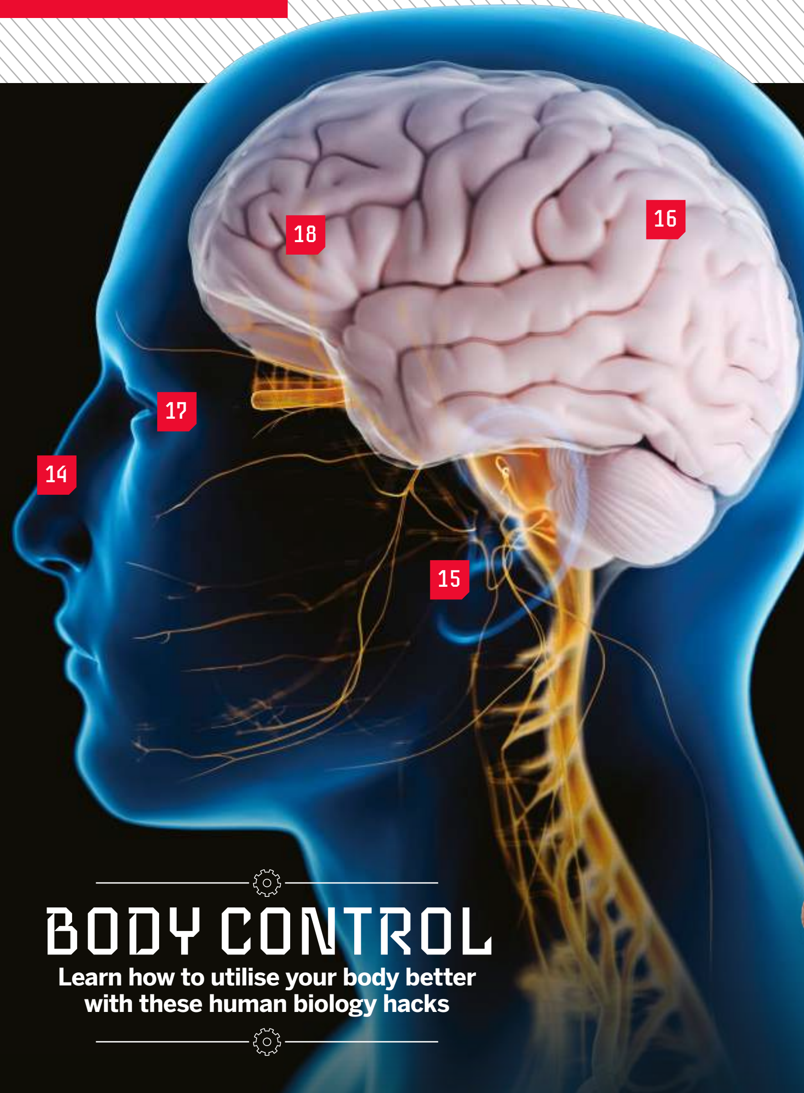
12 TEARLESS ONIONS

When you cut into an onion, breaking its cells, sulphurous gases are released that can irritate the eyes and cause them to water. Keeping onions in the fridge can reduce the movement of the gas and prevent you crying as much.

13 THE POWER OF LEMONS

If you have cut a fruit, such as an apple or avocado, and want it to stay fresh for the next day, dip the cut surface in lemon juice. Fruit turns brown when exposed to oxygen, causing the enzyme polyphenol oxidase to react. The high acidity of lemon juice prevents this enzyme from working.

© Getty / Alamy / Battery illustration by Ed Crooks



BODY CONTROL

Learn how to utilise your body better with these human biology hacks

STIFLE A SNEEZE

14 Sneezes happen when nerves in the nose send an impulse to the lower brain to contract the muscles in the throat and chest. A sneeze consists of two stages, called the sensation and respiratory stages. The sensation stage only lasts for a couple of seconds, but this is the crucial time in which you need to act if you want to stifle a sneeze before the reflux kicks in. To stop a sneeze, you need to overpower the impulse with a more intense one. Some methods include rubbing the roof of your mouth with your tongue, pressing the pressure point in between your eyebrows, tapping the top of your nose and pinching your top lip.

HEARING SPEECH

15 When you find yourself in a loud environment, struggling to hear what someone is saying to you, you might be tempted to turn your ear to hear better. But, which ear would you turn? In this case, you should turn your right ear. Scientists have discovered that the right ear is better at processing speech and logic, while the left ear picks up music better.

Did you know?

The human body has over 200 pressure points

MINIMISING MIGRAINES

16 For those suffering from migraines, pain can intrude unexpectedly. Knowing the most effective pressure points can help people feel more comfortable. Pressure points are specific sensitive areas of the body proven to relieve pain when a certain amount of pressure is applied to them. For children, research shows that ear pressure points such as the ear gate are most effective in reducing migraine pain. The ear gate is found at the top part of the ear, where it connects to the temple. Another pressure point to try when suffering from a headache is on the hand, between the base of the thumb and base of the index finger.

SEE IN THE DARK

17 If you've ever needed to go to the bathroom in the middle of the night and struggled to readjust to the dark bedroom, this is for you. When you need to switch quickly from a light to dark room, keep one eye closed the entire time. When you re-enter the dark room, simply switch which eye is closed. The one that wasn't exposed to the light will be better adjusted to see in the dark.

BED ASSOCIATION

18 Scientists have discovered that reading, working or using your phone in bed can interfere with your quality of sleep. In order to get the best night's sleep, you should use your bed primarily for sleeping. This will help your brain to associate being in bed with rest.

DID YOU KNOW? 75 per cent of children and 70 per cent of adults use electronic devices in the bedroom

Baking soda and vinegar are often used to clean other parts of the kitchen, too

19

DRAIN UNBLOCKING

When drains become clogged, people often resort to using corrosive drain cleaning products. If you want to try a method with less harsh chemicals, try out this hack. Sprinkle a handful of baking soda down the drain, followed by twice as much vinegar. Baking soda and vinegar are at opposite ends of the pH scale, which measures how acidic or alkaline a substance is. When the two substances are combined in the drain, they begin to react with each other, releasing bubbles of carbon dioxide. As this reaction takes place in the drain, it can dislodge food and break up clogs.

20

If the object is bigger than the container, cover a sponge in cola to soak it

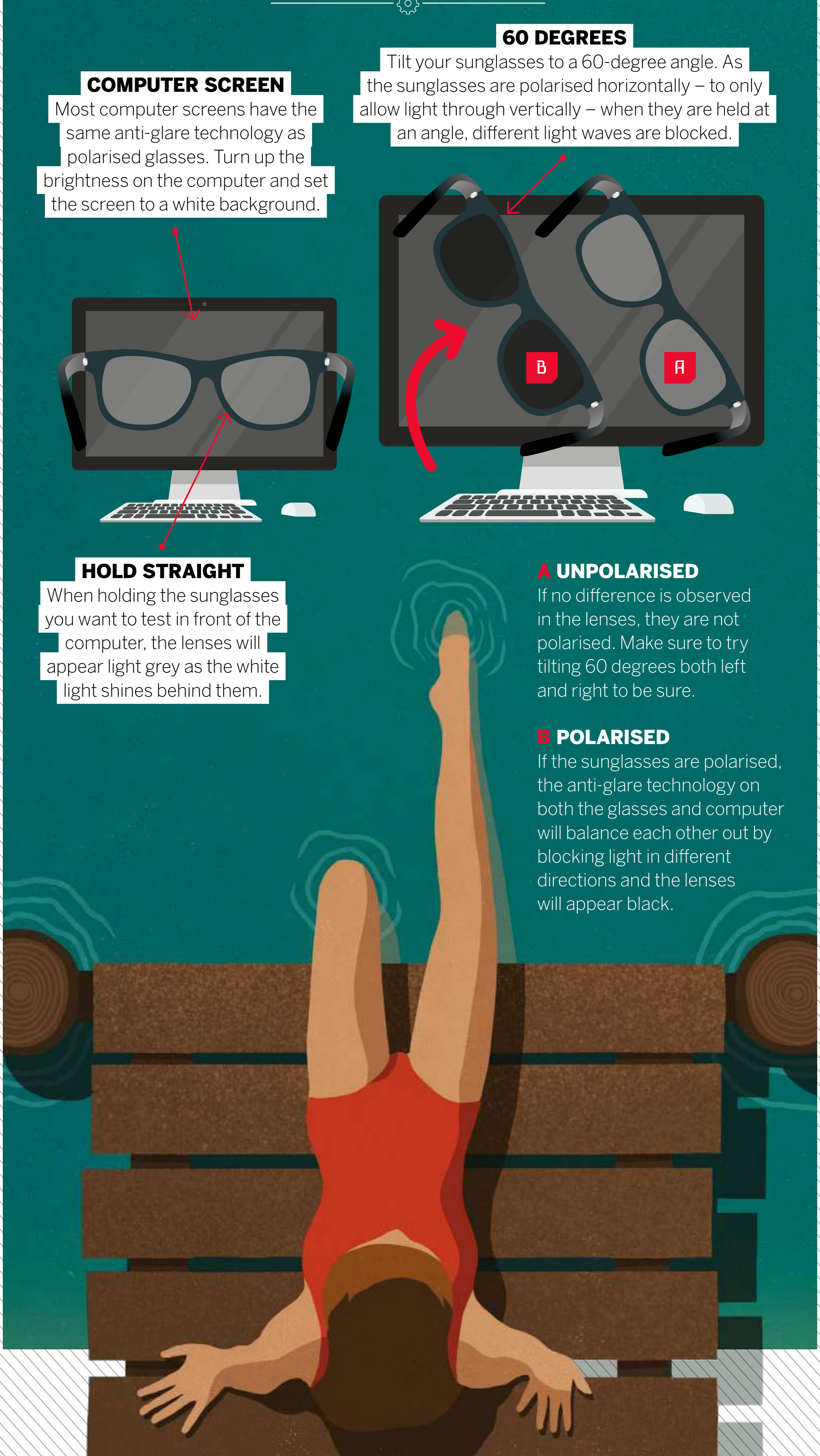
THE DRINK THAT CLEANS

Thanks to the chemistry of cola, this soft drink can be used to remove rust from various objects. The phosphoric acid in the drink reacts with iron oxide in metal to dissolve rust and tarnish. To return a metal object to its original, shiny state, submerge it in cola for 24 hours. After this time, any remaining tarnish can be rubbed off easily with a scrubbing pad. Finally, rinse the metal to remove any sugary remnants and throw away the liquid to make sure nobody mistakes this rust-tainted cola for a refreshing drink.

21

TEST YOUR SUNGLASSES

Do your glasses have an anti-glare filter? Find out in a matter of seconds



COMPUTER SCREEN

Most computer screens have the same anti-glare technology as polarised glasses. Turn up the brightness on the computer and set the screen to a white background.

60 DEGREES

Tilt your sunglasses to a 60-degree angle. As the sunglasses are polarised horizontally – to only allow light through vertically – when they are held at an angle, different light waves are blocked.

HOLD STRAIGHT

When holding the sunglasses you want to test in front of the computer, the lenses will appear light grey as the white light shines behind them.

A UNPOLARISED

If no difference is observed in the lenses, they are not polarised. Make sure to try tilting 60 degrees both left and right to be sure.

B POLARISED

If the sunglasses are polarised, the anti-glare technology on both the glasses and computer will balance each other out by blocking light in different directions and the lenses will appear black.

© Getty

HOW DO ELECTRIC KETTLES WORK?

These are the components inside a kettle responsible for bringing it to a boil

WORDS **AILSA HARVEY**

People have been boiling water for thousands of years for purposes such as killing bacteria, cooking or brewing a drink. Whereas some of our early ancestors would have needed to build an open fire to get their water bubbling, today we can boil water in a couple of minutes simply by using a kettle. Electric kettles convert electrical energy into heat energy, and this is transferred to the water much more efficiently than by an open fire. While an open fire allows heat to escape into the surrounding air, kettles include a lid to trap the heat inside and insulation around the element that heats the water.

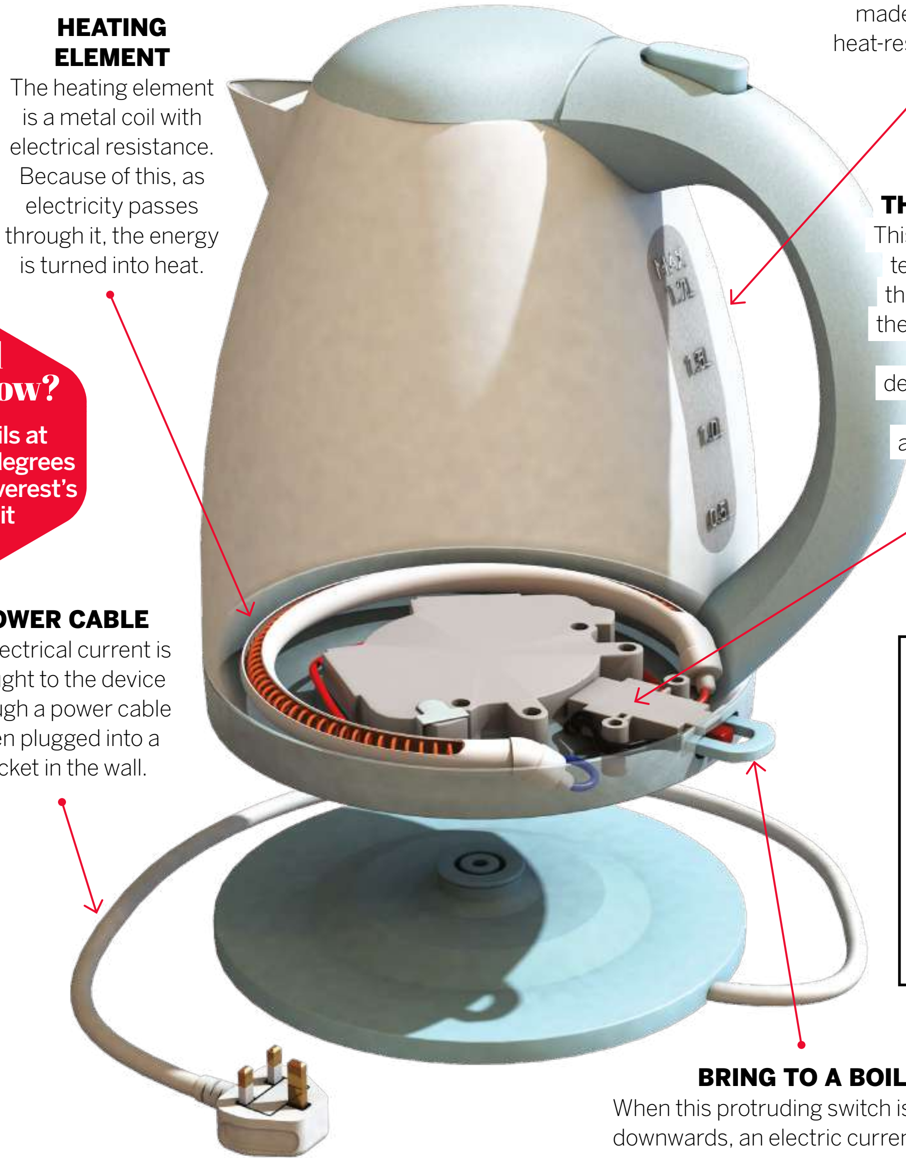
You'll know when the water in a kettle is nearly ready to use because the noise of the water approaching boiling point will increase significantly. This sound is caused by the bubbles being created in boiling water. When boiling, water gains energy from the heat produced. The water molecules begin to move more quickly until they have too much energy to remain as a liquid. When this happens, the water becomes a gas, in the form of water vapour, and floats to the surface. This displacement of water, along with the popping of bubbles as they reach the surface, provides the signature sound of a boiling kettle.

Did you know?

Water boils at around 68 degrees Celsius at Everest's summit

INSIDE THE APPLIANCE

Electric kettles use a by-product of electrical resistance to heat the water inside



HEATING ELEMENT
The heating element is a metal coil with electrical resistance. Because of this, as electricity passes through it, the energy is turned into heat.

MATERIAL CHOICE
The housing of kettle components is usually made from steel. The outer housing can be made of metal or heat-resistant plastic.

THERMOSTAT
This measures the temperature of the water. When the water reaches about 100 degrees Celsius, the kettle automatically turns off.

POWER CABLE
An electrical current is brought to the device through a power cable when plugged into a socket in the wall.

BRING TO A BOIL
When this protruding switch is pushed downwards, an electric current begins to flow through the heating element.

AR zone

SCAN HERE

BOILING AT ALTITUDE

Because the boiling point of water decreases with lower air pressure, when used at high altitudes a standard kettle will never trigger the thermostat to automatically turn off. Water boils at 100 degrees Celsius at sea level; at 150 metres above sea level, its boiling point is lowered by about 0.5 degrees Celsius, continuing to reduce as altitude increases. If you want to make a cup of tea when high in the mountains, a variable temperature kettle is a good solution. This enables the user to alter the temperature setting depending on their elevation, allowing the kettle to automatically trip when the water boils.

Water boils quicker at higher elevations due to the lower atmospheric pressure

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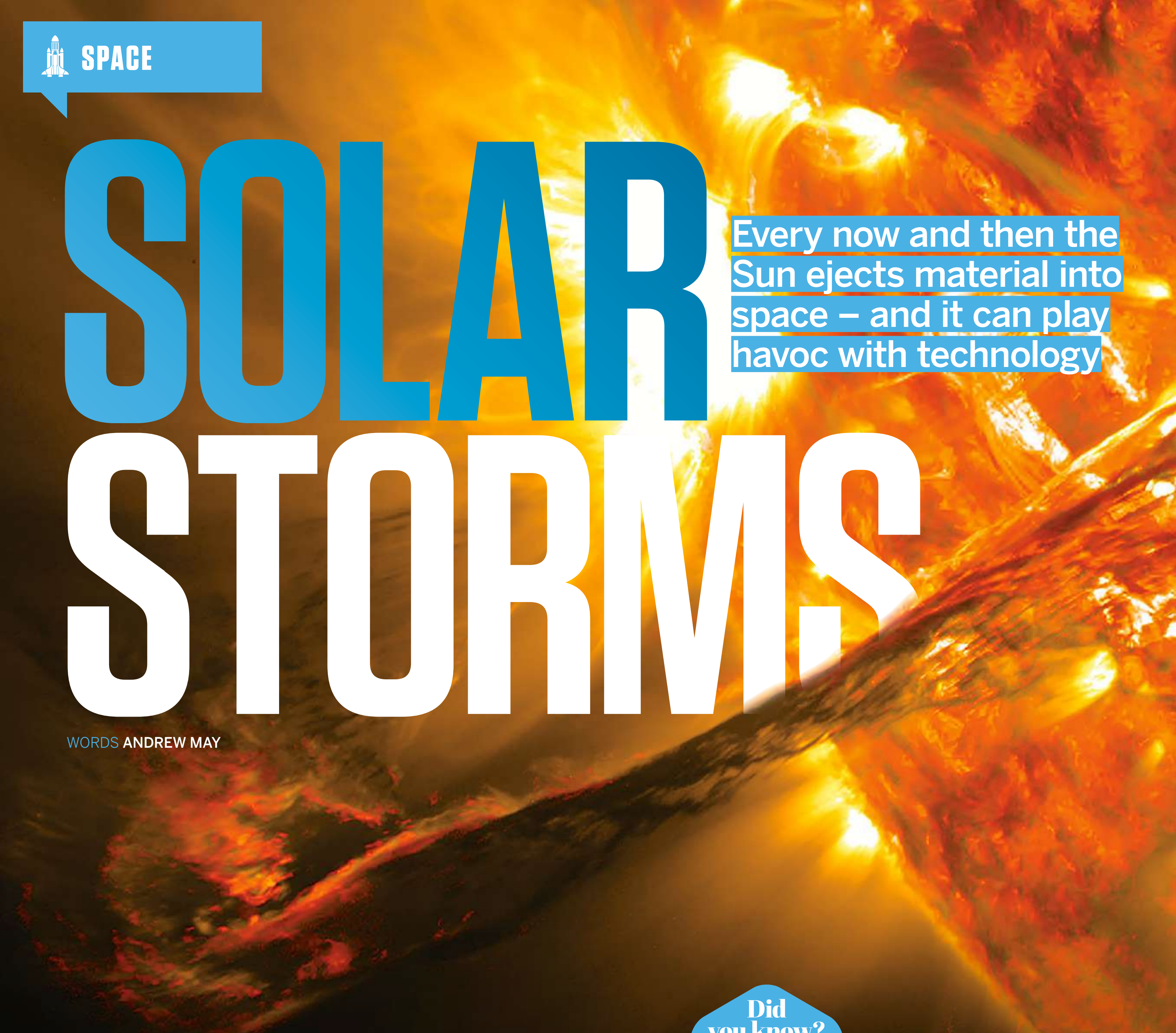


SOLAR STORMS

Every now and then the Sun ejects material into space – and it can play havoc with technology

WORDS **ANDREW MAY**

Fortunately for life on Earth, the Sun is remarkably constant in the heat and light it radiates. In more subtle ways, however, our star is much more capricious. It can blast matter out into space in a way that for most of human history people have been blissfully unaware of. Today, though, such phenomena, known as space weather, can have drastic effects on the satellites and electronic technology we rely on. The origins of space weather can be traced to contortions in the Sun's magnetic field, leading to dark blotches, or 'sunspots', on its surface. It's from these spots that solar flares, coronal mass ejections (CMEs) and other electromagnetic phenomena can emerge – with potentially hazardous consequences for our technological way of life. Sunspot activity rises and falls on an 11-year cycle, and we're currently approaching the next solar maximum in 2025. Now is a good time to look at the worst space weather that the Sun can throw at us, in the form of solar storms.

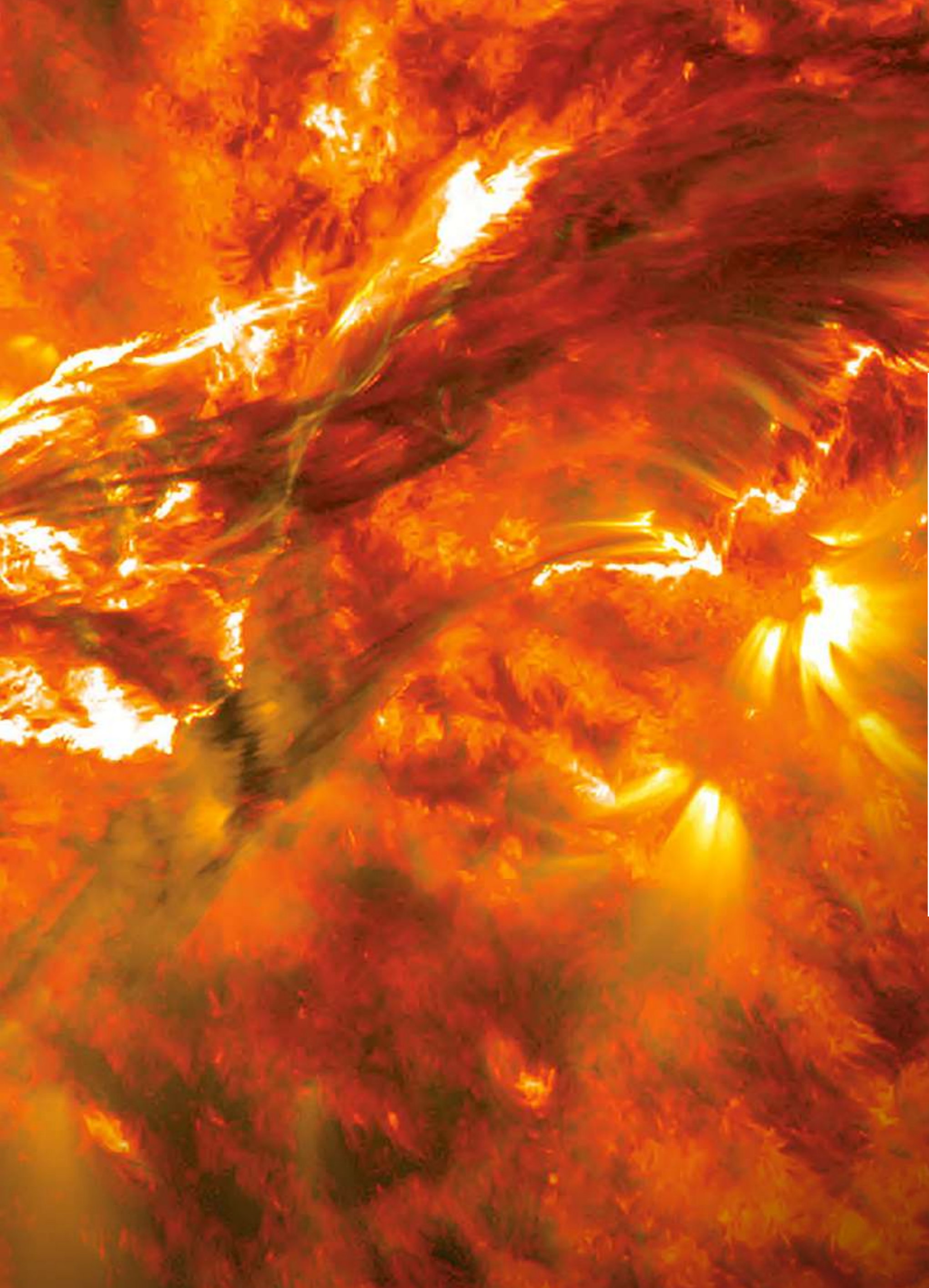
While space weather ultimately originates on the Sun, the term 'solar storm' refers to occurrences on or near our planet, when material thrown out by the Sun reaches us. There are two distinct types of solar storms: geomagnetic storms and solar radiation storms. The first – and most important – of these occurs when a clump of solar material, called a coronal mass ejection, disrupts the Earth's magnetic environment. The second refers to a stream of much faster moving particles ejected by the Sun. As dangerous as the latter sounds, we're largely protected from the effects by the geomagnetic field, as are the majority of satellites in Earth orbit. As a consequence, solar radiation storms are only a really serious problem for deep-space missions. The largest CMEs can contain billions of tonnes of solar material and fly out from the Sun at up to 1,865 miles per second. They contain an embedded magnetic field, and it's this that can play havoc with the Earth's own magnetic field if and when it makes contact.

Did you know?

The fastest CMEs can reach Earth in about 15 hours

We know that this has been happening since time immemorial; a study reported in January 2022 revealed that a powerful solar storm which pummelled Earth 9,200 years ago left radioactive particles in the ice deep below Greenland that are still there to this day. An earlier study from 2020 suggested

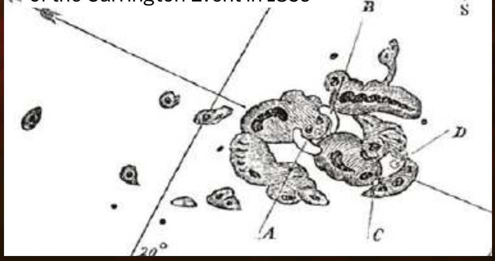
DID YOU KNOW? Sunspots big enough to be seen with the naked eye were recorded by Chinese astronomers over 2,000 years ago

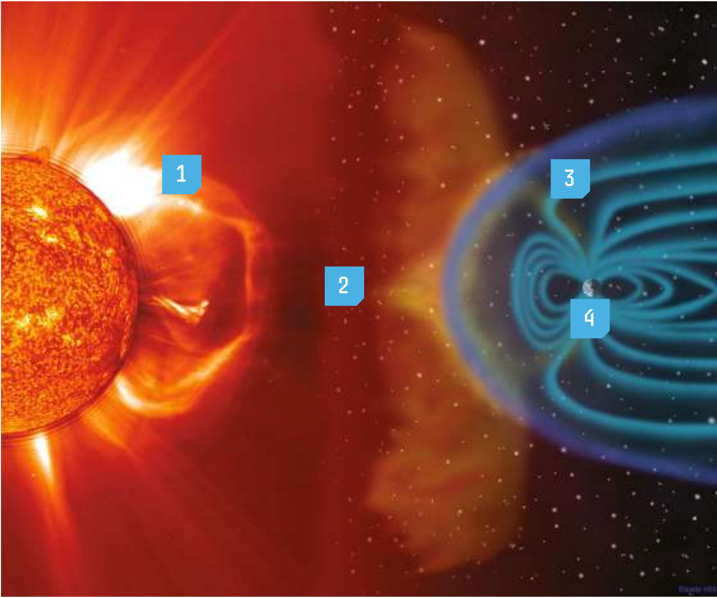


that severe geomagnetic storms occurred in 42 of the preceding 150 years – far more often than had previously been thought.

Perhaps the most famous solar storm of all occurred at the beginning of September 1859, just a few months before the solar maximum of 1860. During August 1859, astronomers around the world had been watching with fascination as the number of sunspots grew, among them Richard Carrington in Redhill, Surrey. On 1 September as he was sketching the sunspots, he was lucky enough to see a sudden flash of light – a solar flare – emanate from them. It was almost certainly accompanied by a CME, because the next day Earth experienced an unprecedented geomagnetic storm, with telegraph systems going haywire and auroral displays, normally confined to the most northerly latitudes, visible in the tropics. Carrington put two and two together and realised that the solar flare he'd seen was almost certainly the cause of this massive geomagnetic disturbance – a connection that had never previously been made. The solar storm of 1859 is now known as the Carrington event in his honour.

Carrington's drawing of sunspots at the peak of the Carrington Event in 1859





MASSIVE EJECTION

If one heads our way, a really large CME could cause disruption on Earth

1 CORONAL MASS EJECTION
Part of the Sun's outer corona is blasted out into space.

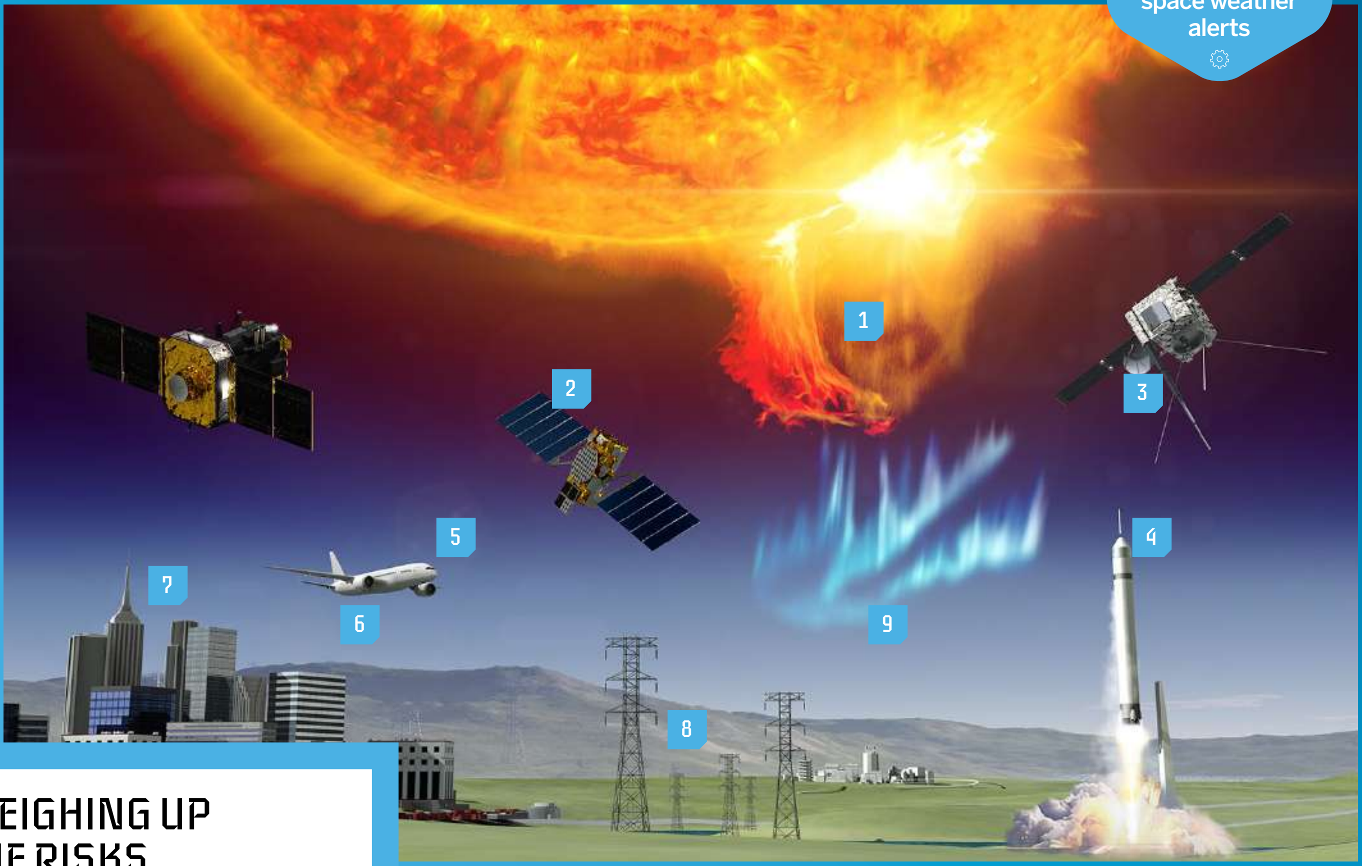
2 CME TRAVELS THROUGH SPACE
The CME may not be heading our way, but if it is it will take two to four days.

3 EARTH'S MAGNETIC FIELD
This deflects much of the material in the CME, preventing it from reaching Earth.

4 EARTH'S SURFACE
The effects of a really powerful CME can break through the magnetic field and disrupt electrical systems.

© NASA / ESA / Wiki: Richard Carrington

Did you know?
The UK's Met Office provides space weather alerts



WEIGHING UP THE RISKS

America's National Oceanic and Atmospheric Administration ranks geomagnetic storms on a scale running from G1, causing an increase in auroral activity and minor fluctuations in power supplies, up to G5, which includes extreme cases like the Carrington event. In the middle of the scale, G3 storm warnings are relatively common; there was one at the end of March 2022. Even a G2 event is capable of causing havoc, like when SpaceX lost 40 satellites in February 2022 when a G2 storm prevented them reaching their intended altitude. While solar storms rarely pose a direct threat to human life, there's a risk they can impact safety-critical systems via electromagnetic effects – from space-based communications, navigation and weather forecasting services to electrical power distribution at ground level.

Satellites are particularly vulnerable to the effects of solar storms

SOLAR STORMS AND TECHNOLOGY

Severe space weather events can cause widespread disruption to satellites, aircraft and ground-based systems

A composite image of the Sun produced by the Solar Orbiter spacecraft in March 2022

1 CORONAL MASS EJECTION
A CME consists of material blasted out from the surface of the Sun. This outburst can sometimes head in the direction of our planet.

2 SOLAR PANEL DEGRADATION
Space weather takes a steady toll on a satellite's solar panels, which generate less and less power over time.

3 SATELLITE DAMAGE
Electronic systems in satellites can also suffer damage, especially during severe solar storms.

4 ASTRONAUT IRRADIATION
Although astronauts are subject to relatively low levels of radiation, it can have a cumulative effect on long-duration missions.

5 NAVIGATION ERRORS
Solar storms can disrupt satellite navigation services, causing serious consequences for aircraft and other vehicles that rely on them.

6 CREW AND PASSENGER IRRADIATION
This is only a serious hazard for people who spend a lot of time flying at high altitude.

7 SATELLITE RECEPTION
Satellite communication systems, including satellite TV, can also fall victim to space weather events.

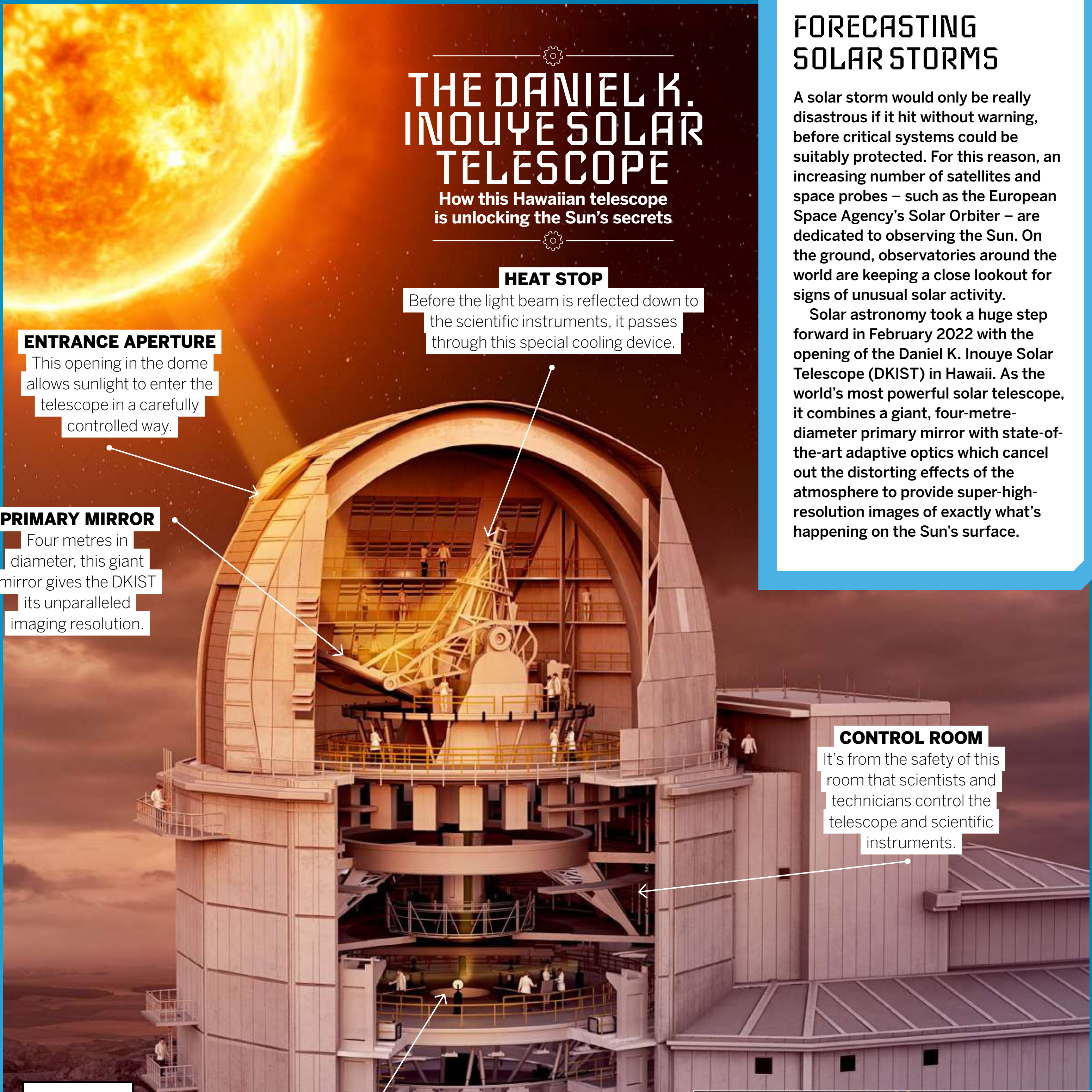
8 POWER GRID
A solar storm can induce stray currents in electrical power lines, leading to disruption of power supplies.

9 AURORA BOREALIS
On a positive note, solar activity can produce spectacular auroral displays at high latitudes.

DID YOU KNOW? A geomagnetic storm caused the collapse of the power network in Quebec, Canada, in March 1989

THE DANIEL K. INOUYE SOLAR TELESCOPE

How this Hawaiian telescope is unlocking the Sun's secrets



HEAT STOP
Before the light beam is reflected down to the scientific instruments, it passes through this special cooling device.

ENTRANCE APERTURE
This opening in the dome allows sunlight to enter the telescope in a carefully controlled way.

PRIMARY MIRROR
Four metres in diameter, this giant mirror gives the DKIST its unparalleled imaging resolution.

CONTROL ROOM
It's from the safety of this room that scientists and technicians control the telescope and scientific instruments.

SCIENTIFIC INSTRUMENTS
Mounted on a 136-tonne rotating platform, these collect and record telescope data.

AR zone

SCAN HERE

FORECASTING SOLAR STORMS

A solar storm would only be really disastrous if it hit without warning, before critical systems could be suitably protected. For this reason, an increasing number of satellites and space probes – such as the European Space Agency's Solar Orbiter – are dedicated to observing the Sun. On the ground, observatories around the world are keeping a close lookout for signs of unusual solar activity.

Solar astronomy took a huge step forward in February 2022 with the opening of the Daniel K. Inouye Solar Telescope (DKIST) in Hawaii. As the world's most powerful solar telescope, it combines a giant, four-metre-diameter primary mirror with state-of-the-art adaptive optics which cancel out the distorting effects of the atmosphere to provide super-high-resolution images of exactly what's happening on the Sun's surface.

Aurora borealis as seen by astronauts on board the International Space Station

© Alamy / ESA / NASA / Illustration by Nicholas Forder

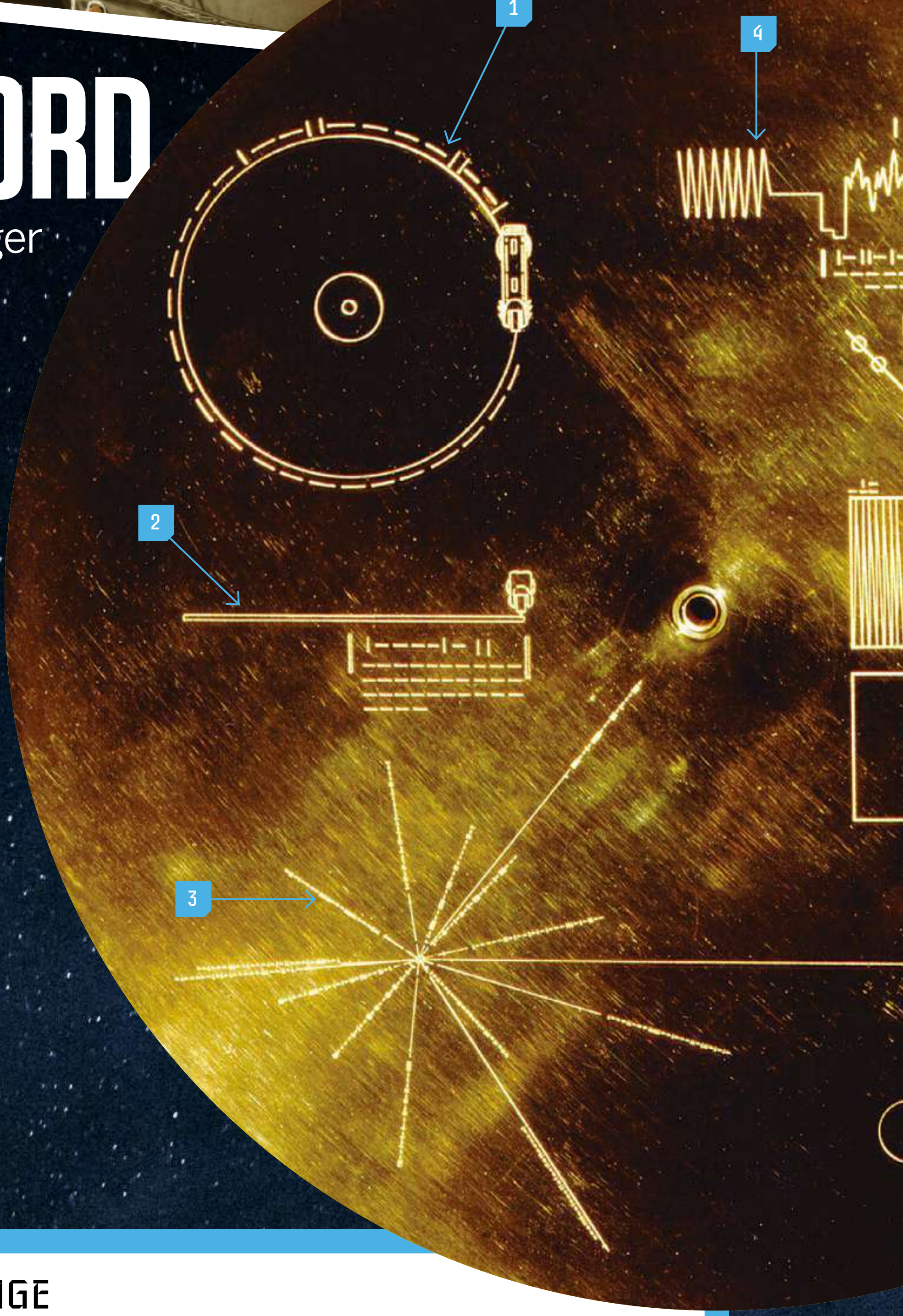
Both were engraved

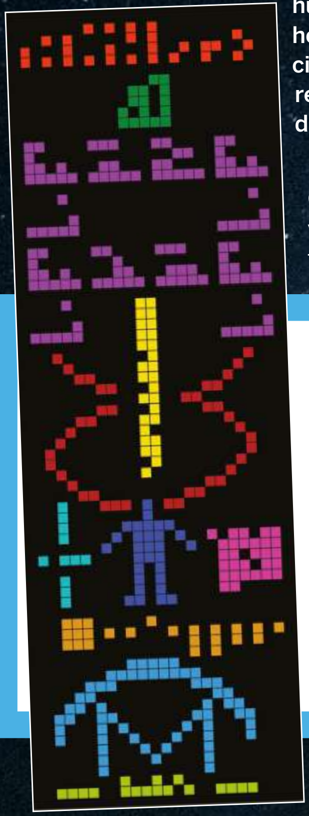
VOYAGER'S GOLDEN RECORD

What information did the Voyager spacecraft carry into space?

WORDS **AILSA HARVEY**

In 1977, two identical copies of a Golden Record were attached to the Voyager 1 and 2 spacecraft, serving as time capsules in space. The NASA-approved idea was to combine the Voyager program, which aimed to gather data from the Solar System and beyond, with a mission to deliver information about life on Earth to any intelligent life forms that may encounter the spacecraft. This is the introductory message – narrated by United Nations' secretary-general Kurt Waldheim – that's heard when the Voyager Golden Record is played: "I send greetings on behalf of the people of our planet. We step out of the Solar System into the universe seeking only peace and friendship, to teach if we are called upon, to be taught if we are fortunate. We know full well that our planet and all its inhabitants are but a small part of this immense universe that surrounds us. And it is with humanity and hope that we take this step." Waldheim mentions the record's potential to allow humanity to teach and be taught. The main purpose of the Golden Record is to share an insight of Earth and to provide evidence of humanity's existence in the hope that another intelligent civilisation in the universe will receive and be able to decipher the information.





Colour has been added to this version of the Arecibo message to separate the sections clearly

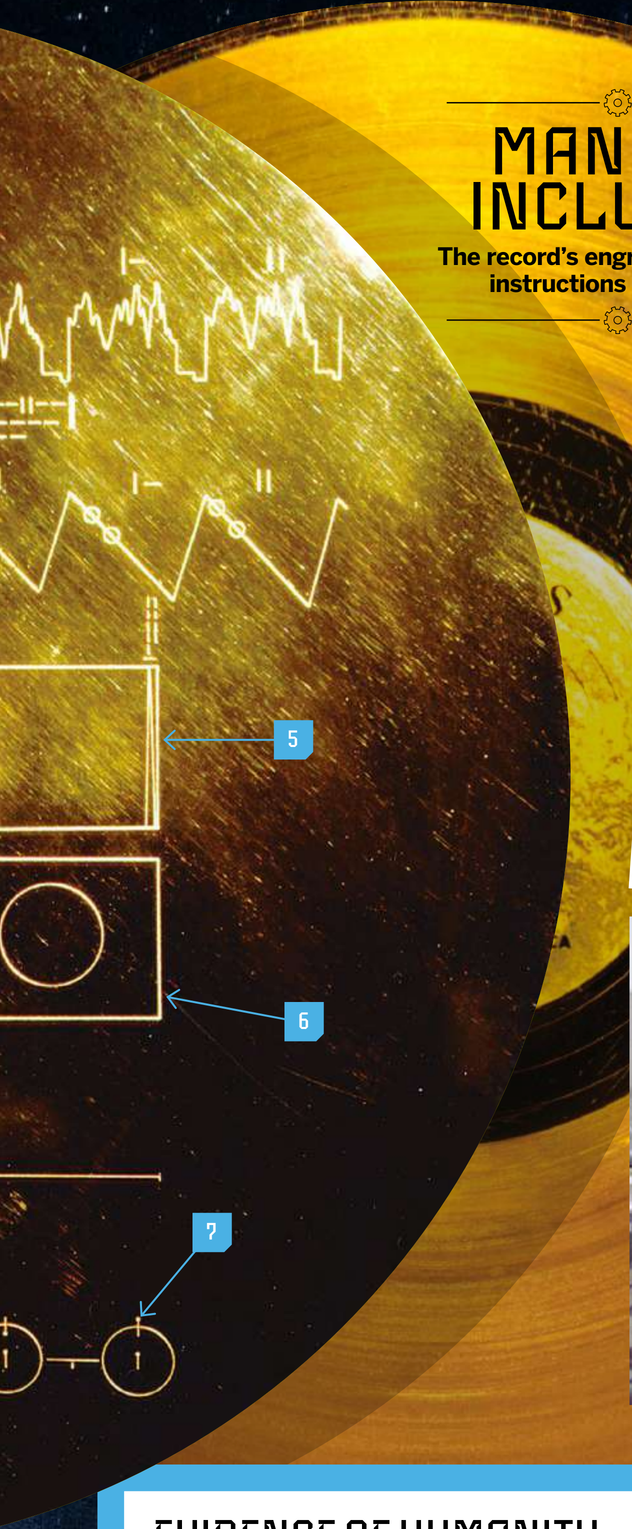
THE FIRST MESSAGE

The first time humans deliberately sent a message to any potential alien civilisations was in 1974, in the form of a coded radio postcard. Called the Arecibo message, this attempted to explain humanity, just like the Voyager Golden Record. In an attempt to choose a language that would be easiest for extraterrestrials to decipher, binary code was used. Using this code, the receiver can reproduce the grid, with the ones and zeros of the binary code symbolising dark and light squares. When pieced together correctly, the shape of the human figure and the number of people on Earth at the time would be produced, as well as other information. The message was broadcast from the Arecibo Observatory in Puerto Rico and also included details about maths, DNA and the Solar System. The Arecibo Observatory was the largest radio telescope in the world at the time the message was sent. When transmitted, the radio message was directed at star cluster Messier 13.

DID YOU KNOW? The Golden Records are 14.5 billion miles (Voyager 1) and 12 billion miles (Voyager 2) from the Sun

MANUAL INCLUDED

The record's engravings include instructions for its use



Did you know?

Each record is 30 centimetres of gold-plated copper disc

1 HOW TO PLAY

This is a diagram of the record to show how it should be played. The position of the stylus that comes with the record can be seen on the right of the circle, showing how to play it from the beginning.

2 SIDE VIEW

Below this side view of the record and stylus are binary numbers indicating how long it will take to play one side of the record. At 3.6 seconds per rotation, one side of the record will play for one hour.

3 PULSAR MAP

Our Solar System, at the centre, in relation to surrounding pulsars – quickly rotating neutron stars releasing radiation. Each line shows the relative distance of each pulsar.

4 PICTURE CONSTRUCTION

This diagram shows how the record produces pictures about Earth. The wavelength graph shows video signals in sequence to form a scan. The diagram illustrates each scan lasting three milliseconds.

5 IMAGE GRID

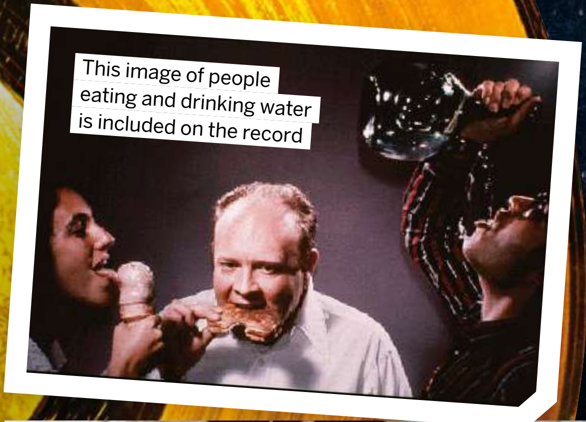
This rectangular image frame shows that each one has 512 lines in it to produce a complete image.

6 SUCCESSFUL IMAGE

This circle shows the first image on the record in order to demonstrate a correctly rendered image.

7 HYDROGEN ATOM

These two circles are drawings of hydrogen atoms at their two lowest energy states. The line connecting the two shows the transition between the two states, serving as a timescale for the record's images.



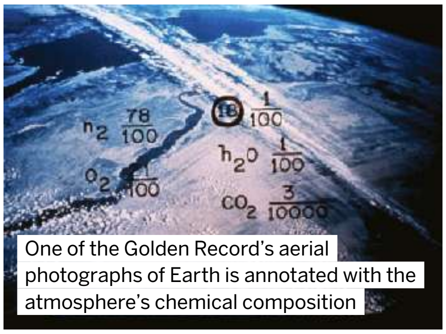
This image of people eating and drinking water is included on the record

ENERAL DYNAM
Convair Division

Voyager project manager John Casani stands with the Golden Record and its golden cover

EVIDENCE OF HUMANITY

As both Voyager spacecraft have entered interstellar space, the Golden Records have left the Solar System. One day, the information compiled here may be the last remaining evidence of humanity. This evidence includes 115 encoded photographs, 55 greetings in global languages, a 12-minute recording of sounds from Earth and 90 minutes of music. Some of the photographs include silhouettes of a man and a pregnant woman, people eating, the Taj Mahal, an aerial photograph of Earth, an image of Pluto, Olympic sprinters racing on a track and a page from Isaac Newton's book, *The System of the World*. The sounds that were chosen to represent Earth were those of humpback whales, brainwaves, storms, volcanoes and rocket launches. Among the chosen music artists were Mozart, Beethoven, Chuck Berry and electrical composer Laurie Spiegel.



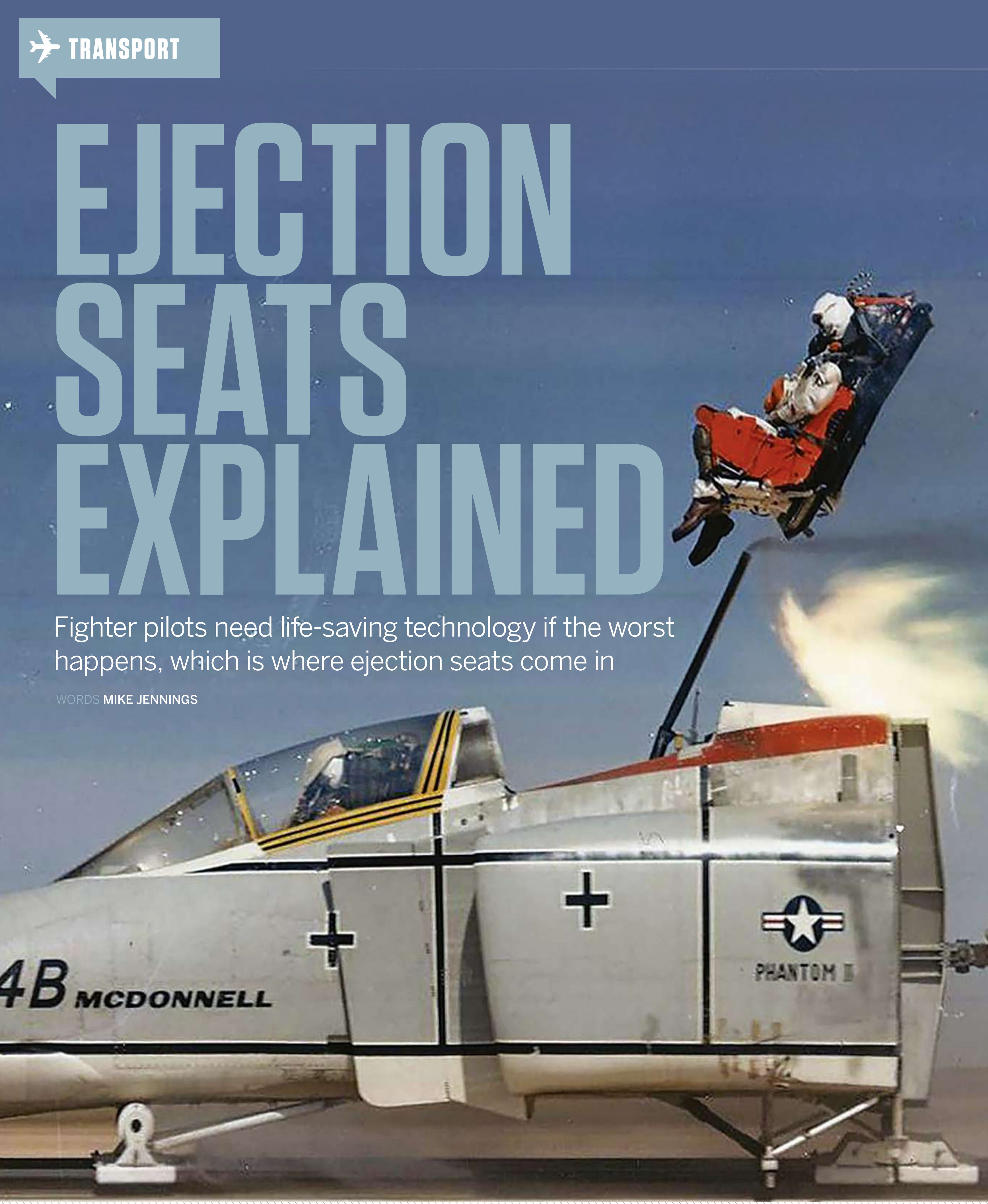
One of the Golden Record's aerial photographs of Earth is annotated with the atmosphere's chemical composition

© Alamy / Getty / NASA/JPL-Caltech / National Astronomy and Ionosphere Center

EJECTION SEATS EXPLAINED

Fighter pilots need life-saving technology if the worst happens, which is where ejection seats come in

WORDS **MIKE JENNINGS**


4B MCDONNELL
PHANTOM II

DID YOU KNOW? Ejection seat g-forces can be so extreme that pilots' spines are compressed and shrink slightly

We're all used to seeing planes, but behind that familiarity you'll find an awful lot of groundbreaking technology and some of the world's most advanced safety gear. If you see a military jet soaring overhead, it'll have ejection seats that can save the crew's lives in emergencies. Ejection seats work as the name suggests: they eject pilots from planes if anything goes seriously wrong. They're fast and often brutal mechanisms that never consider comfort, but speed is more important if your plane's about to crash.

Most of the time, ejection seats work by propelling pilots from the cockpit using rocket-powered motors or explosive charges. This system allows seats to accelerate extremely quickly, which gets people out of danger. Once they're clear, the pilot can use a parachute to safely navigate their way to solid ground.

Did you know?
Over 7,000 lives have been saved by ejection seats

Ejection seats are almost always found on military planes – the sorts of jets that can potentially come under fire from enemies. Many planes have more than one seat, and larger planes eject crew members at different angles to avoid mid-air collisions. They're not used on commercial planes – which have more comfortable evacuation systems – though they've occasionally been fitted to helicopters, and some spacecraft also include ejection seats.

These seats are among the most complex bits of kit on any aircraft, but ejection seats work using some simple principles. Pilots grab a handle to trigger an electronic mechanism that releases the cockpit's roof. Systems on the seat measure the plane's speed and aerodynamic pressure and a computer calculates which ejection mode is suitable – different speeds and altitudes require different ejection processes.

A rocket or motor system propels the pilot's seat up guide rails to make sure the seat gets free of the plane safely, and the seat detaches from the plane's vital systems as it accelerates away from the aircraft at frightening speeds – the entire process takes less than two seconds. A small parachute called a drogue unfolds before the main parachute – it slows and stabilises the seat immediately after ejection. Once the pilot is clear of the plane, they're released from the seat. They can then deploy their main parachute and navigate slowly to the ground below. That sounds simple, but there's plenty else going on. Ejection seats usually have oxygen bottles that deploy when the seat is released because pilots often fly so high that the air outside is too thin to breathe normally.

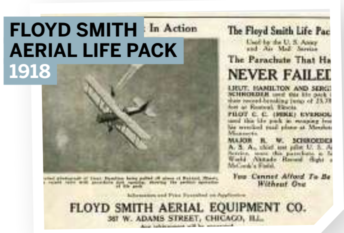
Ejection seats include radio and GPS beacons so the pilot's military can track them down once they've left the plane. The seats also include some vital kit to help pilots survive in any situation. They usually have life rafts and vests that automatically inflate if the pilot has to land at sea, flares for visual identification and sleeping bags, ponchos, hats and gloves for cold environments. These seats often use more comprehensive survival options too, from water and filtration systems to woodland camouflage. It's not uncommon to find mirrors, whistles, candles, insect repellent and even sunscreen in them.

Major seat manufacturers give pilots a tie, patch and certificate to commemorate a successful ejection

WORKING TOWARDS A SAFE LANDING

Ejection seats might be a fixture in modern fighter jets, but they've been around for a long time. Engineers were experimenting with similar systems as early as 1910, and the first modern ejection seats, like the Floyd Smith Aerial Life Pack, were being used by the early 1920s. World War II saw a huge increase in airborne warfare, thus ejection seat designs improved drastically, with German companies leading the way. The first seats used compressed air to remove pilots from cockpits. Other models required gunpowder, and some used the kinds of cartridges that you'd usually see in shotguns. By this point, though, many planes still didn't have ejection seats, so pilots still had to climb free themselves. After World War II, planes got faster, and the need for ejection seats was more pressing. Development continued quickly, with rocket-propelled seats arriving in 1958, and designs have been improving ever since.

FLOYD SMITH AERIAL LIFE PACK 1918


In Action

The Floyd Smith Life Pac

Used by the U. S. Army and Air Mail Service

The Parachute That Ha

NEVER FAILE

You Cannot Afford To Be Without One

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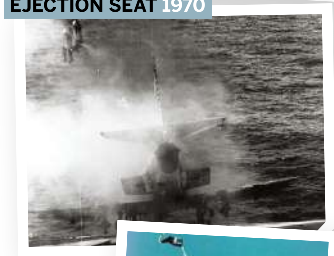
367 W. ADAMS STREET, CHICAGO, ILL.

FOCKE-WULF FW 190 EJECTION SEAT 1943

DOUGLAS A-4E SKYHAWK EJECTION SEAT 1970



MCDONNELL DOUGLAS F-15 EAGLE EJECTION SEAT 2003

© Alamy / Ejection History / We Are The Mighty / US Navy / US Air Force

LAST RESORT

If a pilot is at the point where they're using the ejection seat, it's their last viable course of action – it means that their plane is doomed and they've got no other options. Pilots usually fight until the last possible second to save their plane and themselves, but abandoning an aircraft can be expensive. The Royal Air Force's F-35 Lightning jets cost nearly £90 million ($118 million) each. There are only a few situations where an ejection is necessary. If a jet has been irreparably damaged due to enemy fire then a pilot will have to make a quick getaway, and a pilot may have to eject if the plane has encountered a technical issue in the field or during testing. Different situations need different ejection technology, too, so sensors on the seat determine which mode the plane uses when it flings the pilot into the sky.

MODE ONE

SPEED: **Less than 288 miles per hour**
ALTITUDE: **Less than 4,575 metres**

A low-speed, low-altitude ejection is a simpler affair that doesn't need the small drogue parachute.

MODE TWO

SPEED: **Beyond 288 miles per hour**
ALTITUDE: **Less than 4,575 metres**

This high-speed mode deploys the drogue and protective seat restraints to protect fast-moving pilots at low altitudes.

MODE THREE

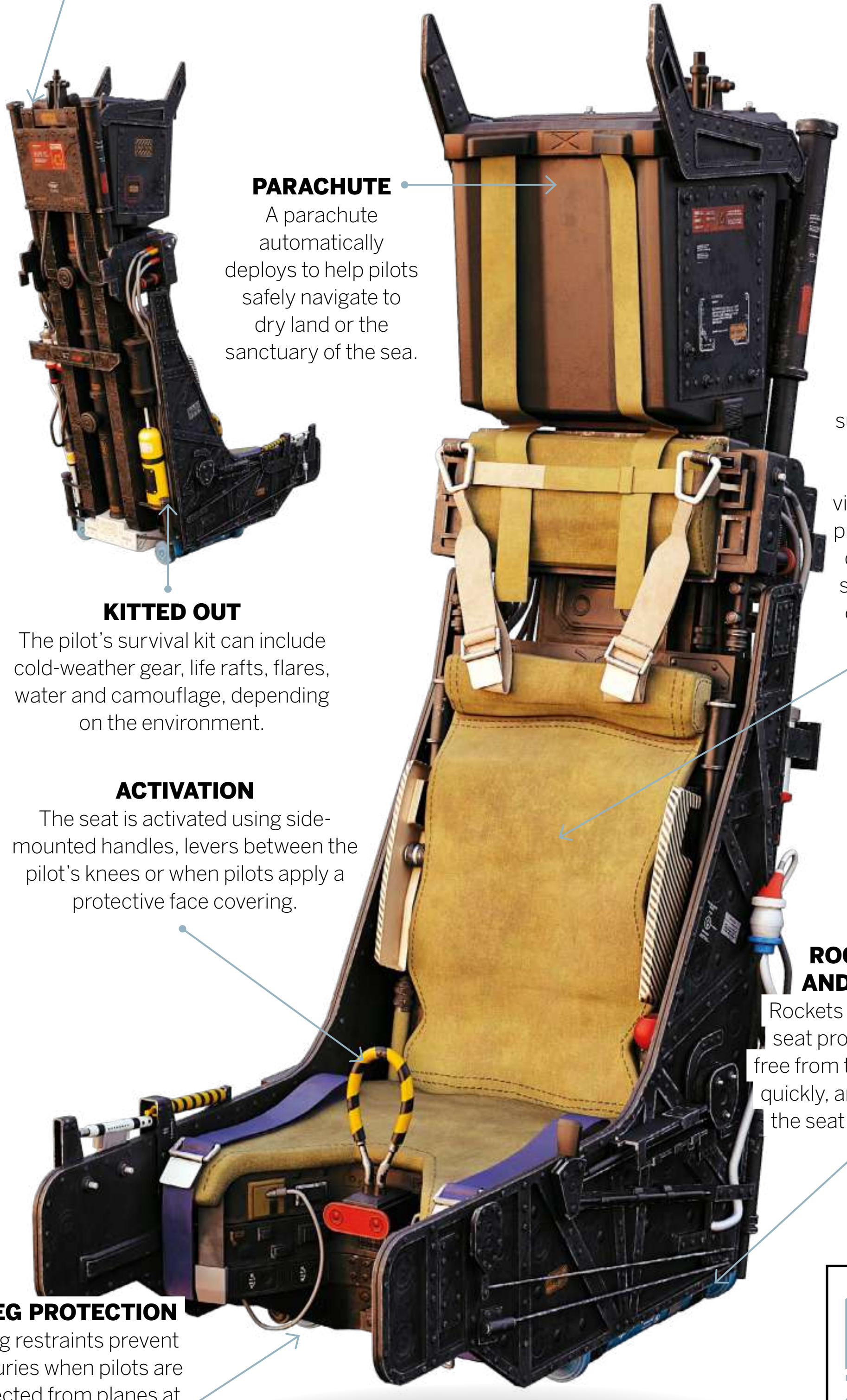
SPEED: **Any speed**
ALTITUDE: **Beyond 4,575 metres**

At high altitudes, the drogue and seat restraints are required alongside an automatic parachute, survival kit and life raft deployment.

> "Ejection seats are fast and brutal, but speed is more important"

VITAL COMPONENTS

Ejection seats are complex. We explore the key technology in these life-saving devices



DROGUE
The drogue is a small parachute that stabilises the seat before the main parachute is required.

PARACHUTE
A parachute automatically deploys to help pilots safely navigate to dry land or the sanctuary of the sea.

BACK TO BASICS
Sturdy back supports keep pilots safe during the violent ejection procedure, but despite that, spinal injuries can happen.

KITTED OUT
The pilot's survival kit can include cold-weather gear, life rafts, flares, water and camouflage, depending on the environment.

ACTIVATION
The seat is activated using side-mounted handles, levers between the pilot's knees or when pilots apply a protective face covering.

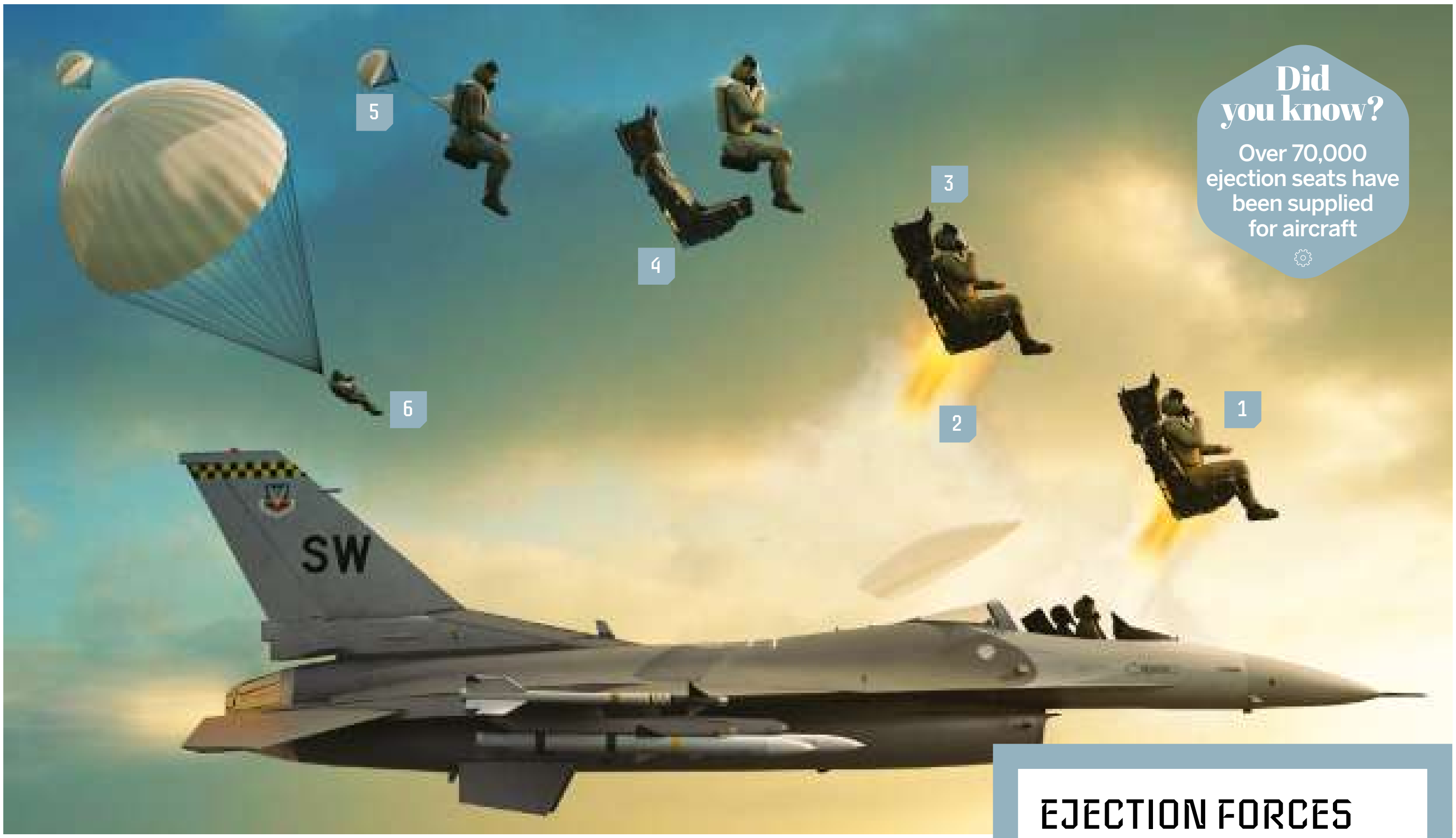
ROCKETS AND RAILS
Rockets beneath the seat propel the pilot free from the plane very quickly, and rails guide the seat to freedom.

LEG PROTECTION
Leg restraints prevent injuries when pilots are ejected from planes at extreme speeds.

AR zone

SCAN HERE

DID YOU KNOW? Zero-zero seats eject pilots safely when they're in trouble on the ground at zero altitude and speed



Did you know?

Over 70,000 ejection seats have been supplied for aircraft

HOW THEY WORK

It's a split-second process, but what actually happens when a pilot makes an emergency exit?

1 OPEN UP
Pilots pull a lever between their knees or to the side of the chair to release the plane's canopy.

2 ROCKET POWER
Once the roof is free, rockets fire to propel the seat along guide rails. The pilot receives emergency oxygen.

3 GETTING HEIGHT
Ejection seats shoot pilots at least 30 metres into the air, and sometimes as far as 100 metres.

4 FAREWELL
Once the pilot is free from the plane, the ejection seat falls away – it's done its job.

5 SLOW DESCENT
A parachute releases automatically, sometimes only when the pilot has descended to a certain altitude.

6 LANDING STRIP
Pilots use the parachute to navigate to a safe landing, whether it's on land or sea, thanks to an built-in life raft.

Some older seats subjected pilots to 20g of force; humans can't withstand much more

A modern ejection seat can cost between $140,000 and $400,000 (£182,900 and £522,580) depending on its configuration

EJECTION FORCES

Ejection seats are serious business, with pilots describing an ejection as one of the most violent forces they've ever experienced. And when you consider the physics at play, that's no surprise. Ejection seats propel pilots for between 30 and 100 metres at speeds beyond 250 miles per hour in a process that takes half a second – and when the planes are flying at speeds upwards of 750 miles per hour. These extreme speeds put huge pressure on the human body. Pilots typically experience up to 14G of force when they eject, which means that an 80-kilogram person will experience 1,632 kilograms of pressure on their body. Unsurprisingly, this can cause injuries – it's not unheard of for pilots to break limbs because they're thrown around so violently thanks to ejection seat g-forces.

DANGER
UPWARD EJECTION SEAT
DANGER
DANGER
FORCE

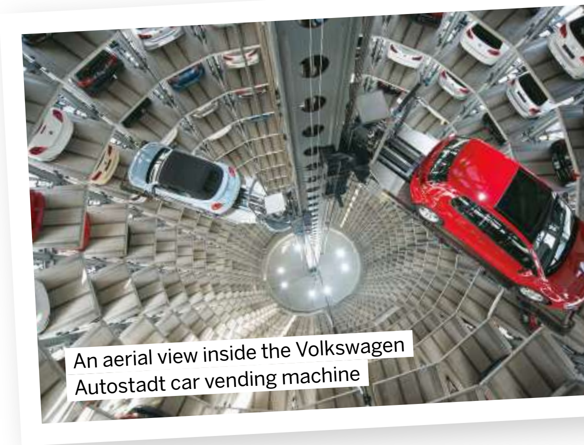
Ejection seats use explosives and extreme force, so warnings are needed

© Getty / Illustrations by Nicholas Forder

CAR VENDING MACHINES

These giant dispensers make buying a car simple

WORDS **SCOTT DUTFIELD**


An aerial view inside the Volkswagen Autostadt car vending machine

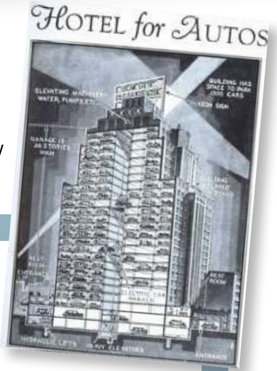
The idea of completing your car purchase in the same way you might buy a snack might seem ludicrous, but in some parts of the world it's very much a reality. In March 2022, car dealer Carvana launched the newest car vending machine in California. The eight-storey car dispenser can hold 27 vehicles and offers customers the chance to shop for their car online and collect it from the machine. The Carvana car vending machine is a fully automated system that works similarly to the snack-dispensing machines we're used to. By inserting a Carvana coin, which is given to customers after purchasing a vehicle, the vending machine locates and carries the car to the delivery bay.

One of the most famous car vending machines can be found at the Autostadt in Wolfsburg, Germany. In 2000, car manufacturing group Volkswagen unveiled a new way to showcase the stages of vehicle production: the Autostadt, meaning 'Automobile City' in German. This visitor attraction – which draws in around 2 million visitors each year – includes a museum of Volkswagen Group vehicles and two 60-metre-tall glass towers filled with sold cars, all waiting for their owners to collect them. Once the cars complete their journey through the manufacturing process in the adjacent Volkswagen factory, they're loaded onto a conveyor belt which takes them to one of the two towers. Once through the tower doors, a mechanical arm will then lift and rotate the car into one of the hundreds of spaces within.

Upon being purchased, the car will be called from its space and brought back to be driven away. The system is fully autonomous, and it takes a record-breaking one minute and 44 seconds from the time a car enters the tower until it reaches the top level. This also means that when someone buys a car from the Autostadt, they drive away in a car that has zero miles on the odometer – the clock that measures the total distance travelled over the car's lifetime.

Did you know?

There are 31 Carvana vending machines in America



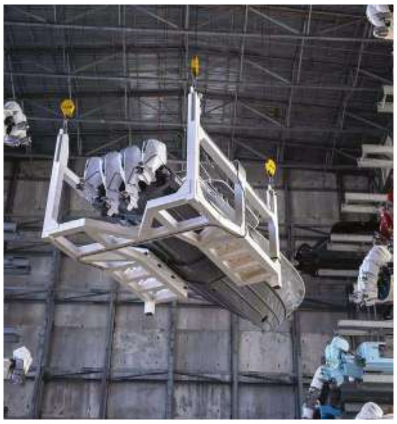
A diagram of the New York car hotel

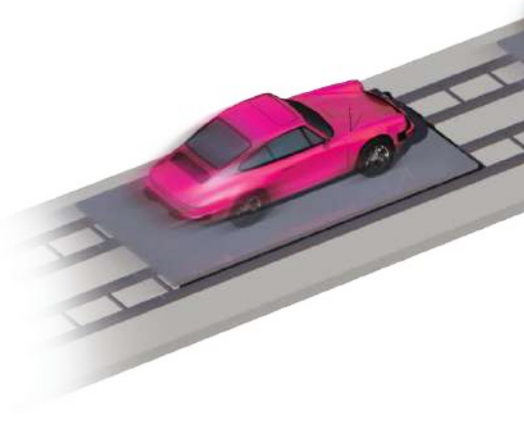
HOTEL FOR AUTOS

Long before Volkswagen and Carvana created their automated vending machines, the early 1900s saw the rise of vertical parking. One of the more luxurious examples could be found in New York, called the Hotel for Autos. This automatic garage was erected in the 1930s and was operated electronically. Cars were driven into a lift shaft, and after a button was pressed the vehicle was lifted on an elevator-like platform up to an available parking level. Once at the specified level, a rubber belt placed beneath the vehicle moved it in and out of a space within the garage. Admission to the Hotel for Autos was a mere 50 cents (around $7 or £5.50 today) for two hours of parking. Unfortunately, the size of commercial cars increased beyond the capacity of the car hotel, and the collapse of the company that owned it caused it to close after only a couple of years.

STORING BOATS

Cars aren't the only vehicles that can be dispensed like a bag of crisps or a chocolate bar. In Fort Lauderdale, Florida, the F3 Marina is a 240-rack facility that can store boats weighing up to around 13,600 kilograms. The marina's fully automated crane system can lift boats from its wet well and carry them into a rack location – the boat's parking spot – in under five minutes. This smart marina can lift and navigate boats up to 14 metres in length and six metres in height at the touch of a button. Similarly to a vending machine, once the boats are ready to collect they are autonomously lowered into the wet well, ready to sail away.


A boat being lifted in the F3 Marina

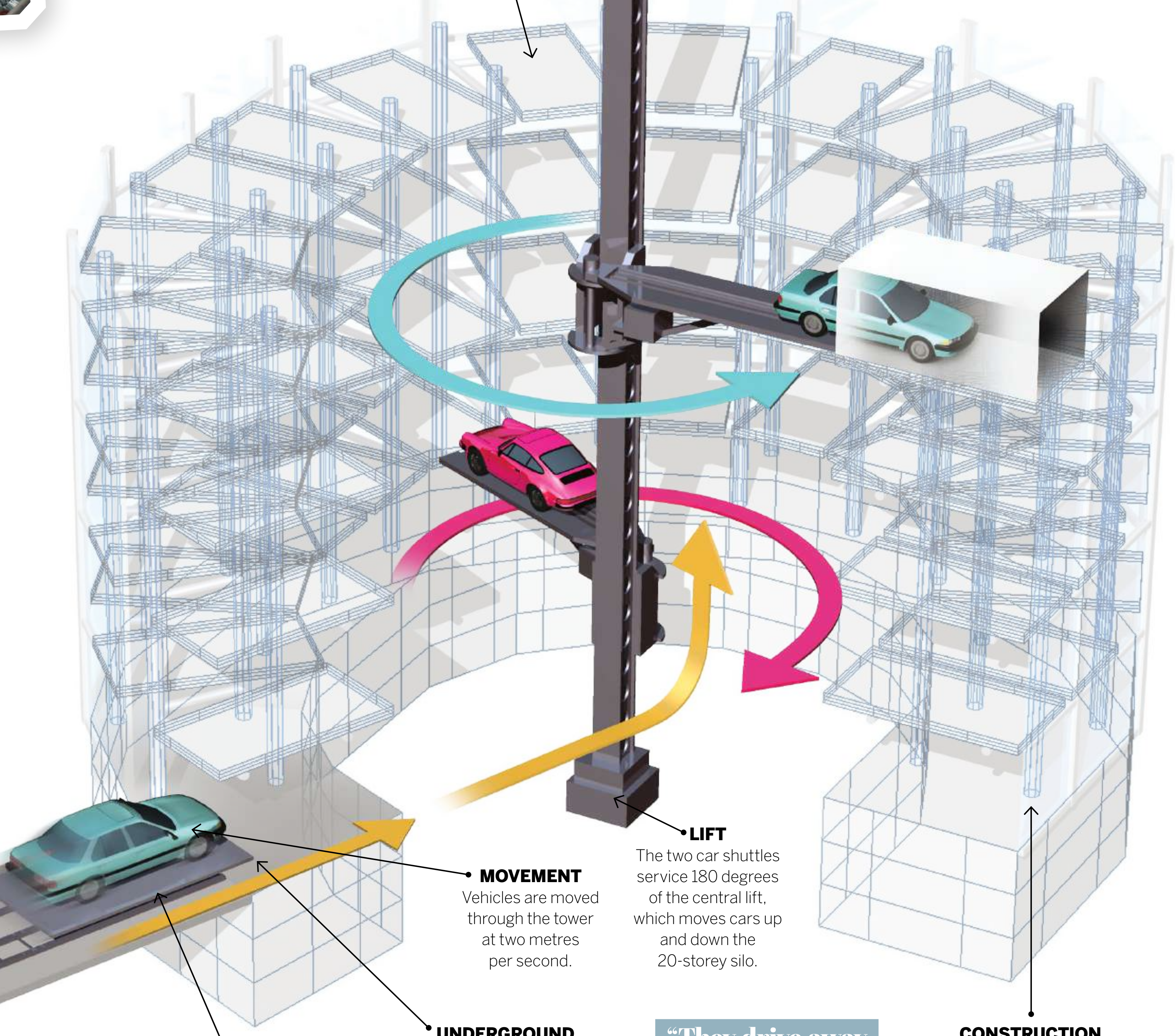


DID YOU KNOW? Each day, an average of 500 cars are delivered to new owners at the Autostadt

INSIDE THE CAR TOWER

How new cars enter the Volkswagen vending machine

A Carvana car vending machine in Maryland



PARKING SPACE
There are 400 spaces within each of the two towers.

MOVEMENT
Vehicles are moved through the tower at two metres per second.

LIFT
The two car shuttles service 180 degrees of the central lift, which moves cars up and down the 20-storey silo.

CAR SHUTTLES
Extending from the tower's central lift are two robotic arms that carry cars upwards.

UNDERGROUND
Cars enter the tower through a 700-metre-long underground converter belt that connects to the Volkswagen factory.

> "They drive away in a car that has zero miles on the odometer"

CONSTRUCTION
Each of the two towers are made from glazed and galvanised steel frames.

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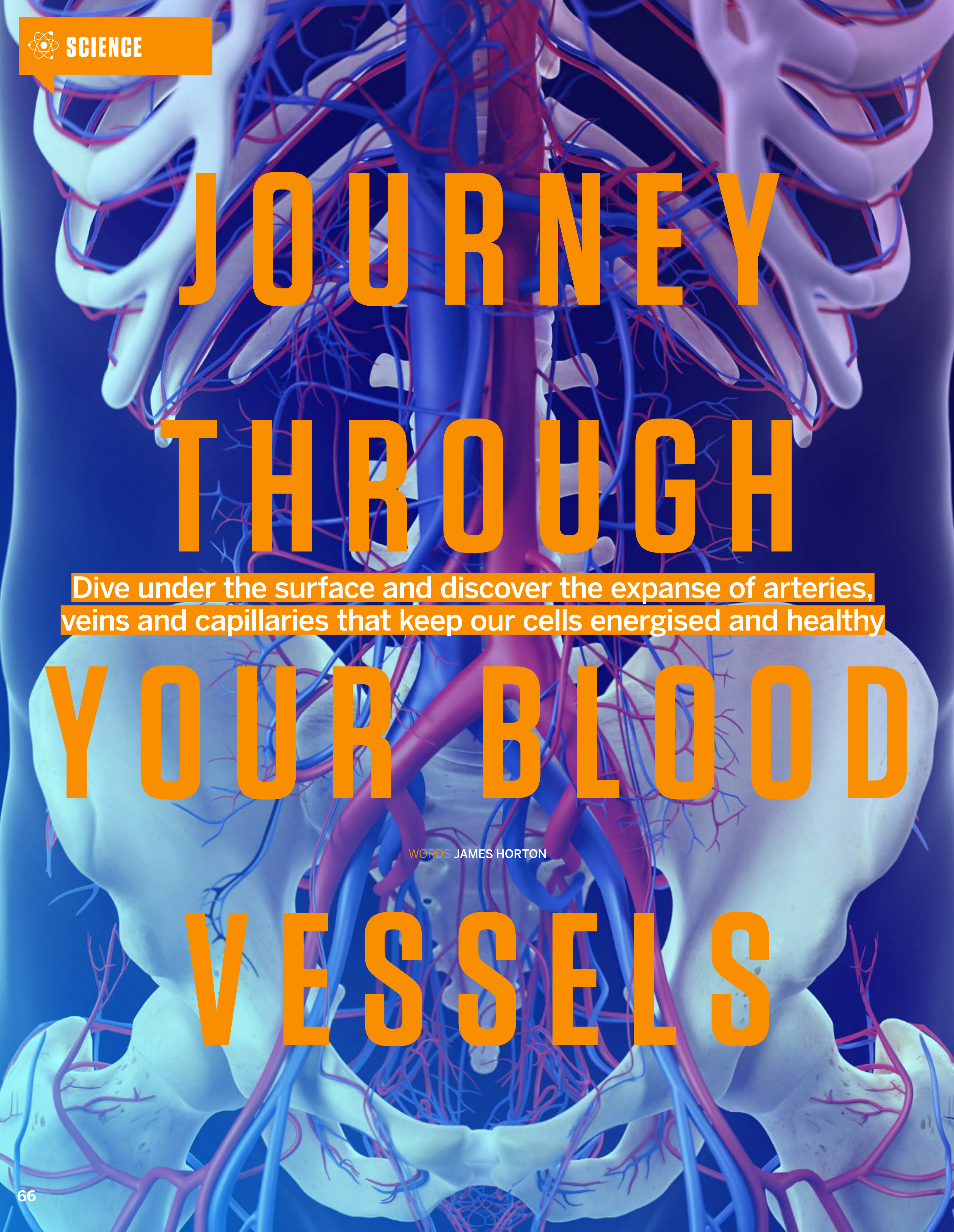


JOURNEY THROUGH YOUR BLOOD VESSELS

Dive under the surface and discover the expanse of arteries, veins and capillaries that keep our cells energised and healthy

WORDS JAMES HORTON

DID YOU KNOW? White blood cells make up just one per cent of blood

Every cell in the human body requires oxygen to produce energy, but most of our cells cannot access it directly. A single-celled life form interacts directly with its environment, exchanging nutrients and waste products as required. But our ancestors gave up that lifestyle hundreds of millions of years ago when they evolved to become multicellular.

As multicellular life grew more sophisticated, our ancestors' cells became specialised and compartmentalised. Then, many millions of years later, their descendants migrated from the ocean to the land. Gone were the days when even external cells exchanged nutrients with their environment – now our ancestors' cells were encased inside a protective barrier of skin, allowing them to retain their water and maintain consistent internal temperatures. This meant that precious few cells interacted with the environment, and therefore very few cells could access much-needed oxygen and sugars for energy. Fortunately, our species – just like our land-treading ancestors – possesses an interwoven network of tissues and organs dedicated to ensuring our cells acquire the nutrients they need. We call this network the circulatory system.

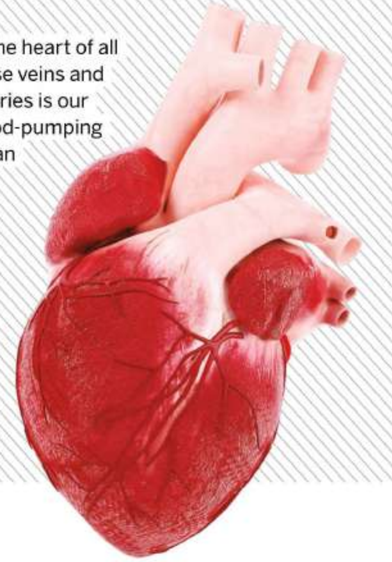
This vascular network consists of a pump – the heart – and a connected network of blood vessels that carry blood to and from internal tissues. If blood and its component parts are the delivery service, busily dispensing oxygen and collecting waste, then blood vessels are the highways and smaller roads on which they travel. Together with the heart, which provides the pressure that propels blood around the circuit in the body, blood vessels are essential for maintaining the health and functionality of our cells. Our circulatory system is also highly adaptable. When we're at rest and require less energy, heart rate slows. However, when we move about and exercise the heart rate rises.

You can feel the beating heart in action for yourself by placing a finger on the left side of your wrist or by softly placing a finger next to the left side of your windpipe. When you do this, you're feeling your pulse through the radial and carotid arteries respectively. As well as the heart, blood vessels themselves react to environmental changes. When it's cold, for example, blood vessels constrict, helping to reduce heat loss. If you've ever suffered brain freeze, blame your protective blood vessels, which constrict as the cold substance hits the roof of your mouth. The reverse is also true, as blood vessels expand when it's hot to help our bodies shed excess heat. As well as supplying the body with gases and nutrients, our vascular network helps regulate our internal environment, helping to both fuel and protect our cells.

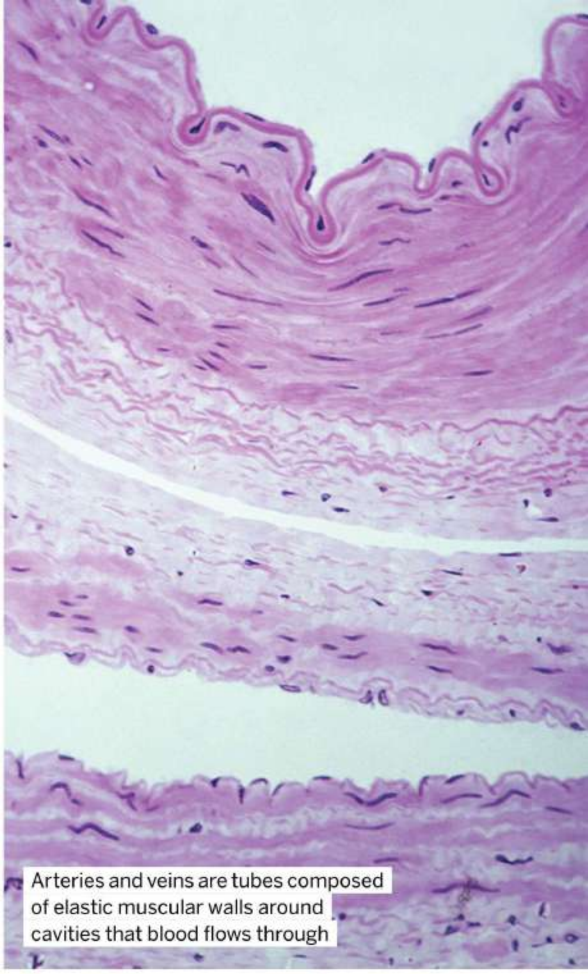
Did you know?

Blood travels around the body in less than 60 seconds

> "An interwoven network of tissues and organs dedicated to ensuring our cells acquire nutrients"



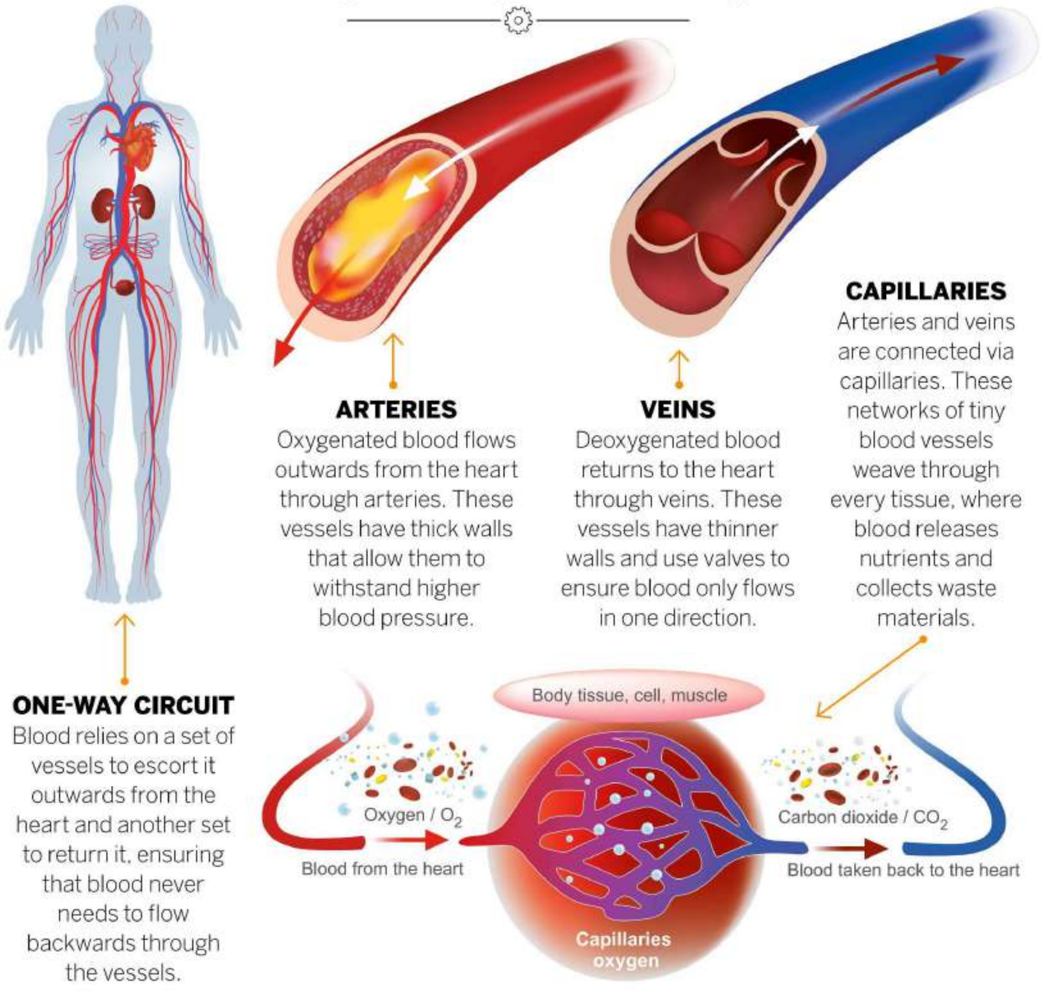
At the heart of all these veins and arteries is our blood-pumping organ



Arteries and veins are tubes composed of elastic muscular walls around cavities that blood flows through

CIRCULATORY COMPONENTS

Blood flows throughout the body via three distinct types of vessels



ARTERIES

Oxygenated blood flows outwards from the heart through arteries. These vessels have thick walls that allow them to withstand higher blood pressure.

VEINS

Deoxygenated blood returns to the heart through veins. These vessels have thinner walls and use valves to ensure blood only flows in one direction.

CAPILLARIES

Arteries and veins are connected via capillaries. These networks of tiny blood vessels weave through every tissue, where blood releases nutrients and collects waste materials.

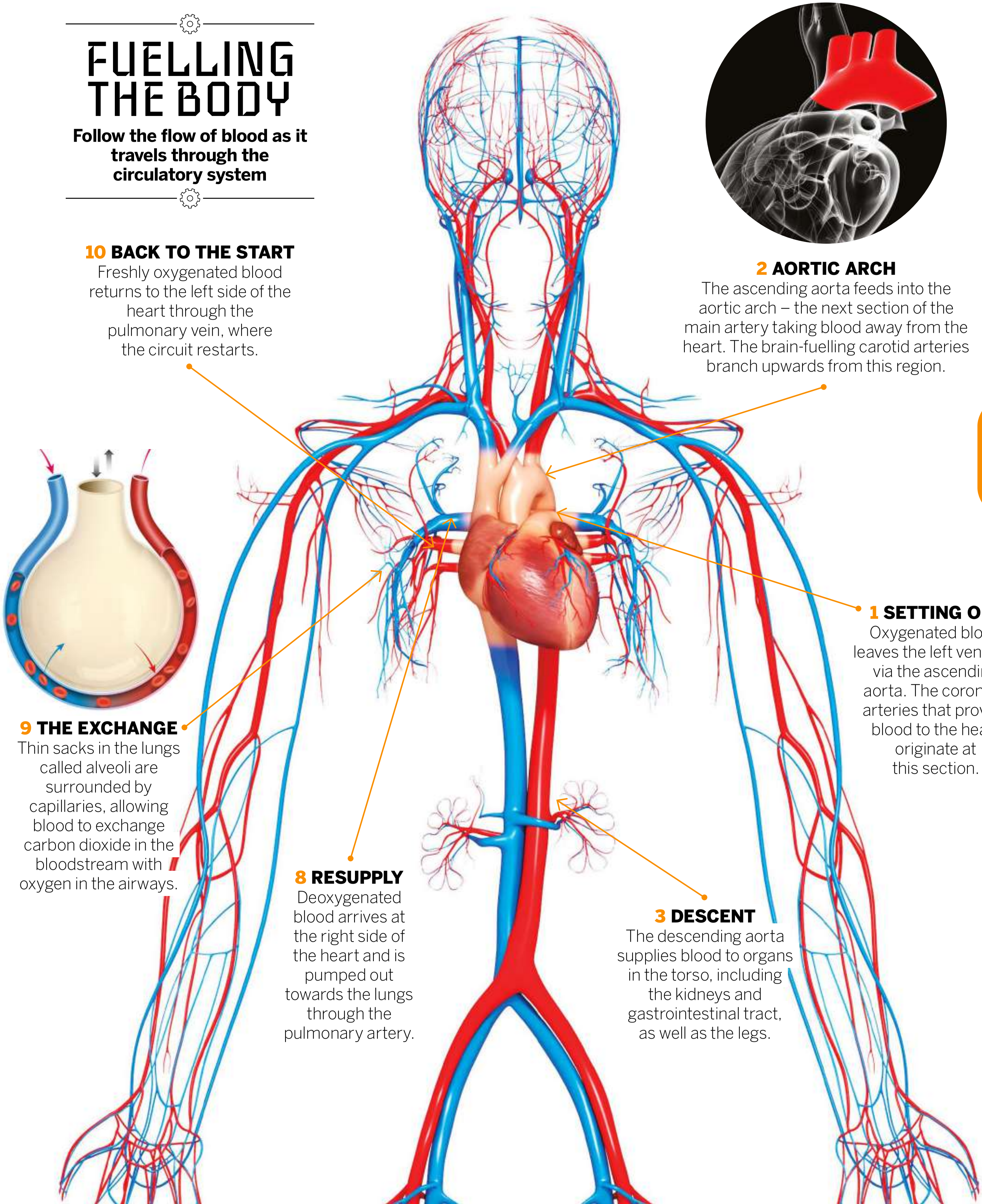
ONE-WAY CIRCUIT

Blood relies on a set of vessels to escort it outwards from the heart and another set to return it, ensuring that blood never needs to flow backwards through the vessels.

© Alamy / Getty

FUELLING THE BODY

Follow the flow of blood as it travels through the circulatory system



10 BACK TO THE START
Freshly oxygenated blood returns to the left side of the heart through the pulmonary vein, where the circuit restarts.

9 THE EXCHANGE
Thin sacks in the lungs called alveoli are surrounded by capillaries, allowing blood to exchange carbon dioxide in the bloodstream with oxygen in the airways.

8 RESUPPLY
Deoxygenated blood arrives at the right side of the heart and is pumped out towards the lungs through the pulmonary artery.

2 AORTIC ARCH
The ascending aorta feeds into the aortic arch – the next section of the main artery taking blood away from the heart. The brain-fuelling carotid arteries branch upwards from this region.

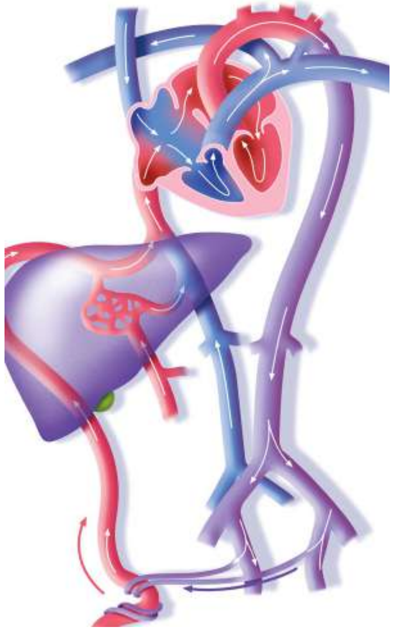
1 SETTING OFF
Oxygenated blood leaves the left ventricle via the ascending aorta. The coronary arteries that provide blood to the heart originate at this section.

3 DESCENT
The descending aorta supplies blood to organs in the torso, including the kidneys and gastrointestinal tract, as well as the legs.

Did you know?
The average adult has about 5.5 litres of blood in their body

CIRCULATION DURING GESTATION

Humans are placental mammals, which means our offspring acquire their nutrients from a placenta during foetal development. Budding embryos swiftly develop a blood supply within the first few weeks of development, but without functioning lungs, kidneys or a gastrointestinal tract, a foetus must rely on its parent for oxygen and nutrients. The maternal blood supply is connected to foetal circulation via the placenta and the umbilical cord, which contains two umbilical arteries and one umbilical vein. The two arteries escort deoxygenated blood from the foetus to the placenta, while the vein carries oxygenated and nutritious blood from the placenta to the foetal heart.

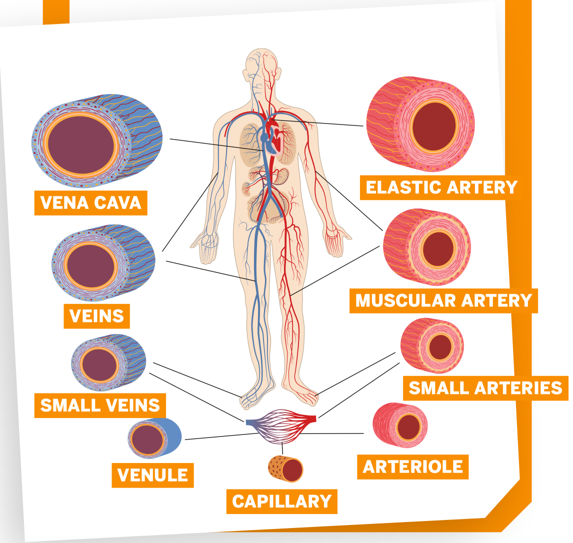


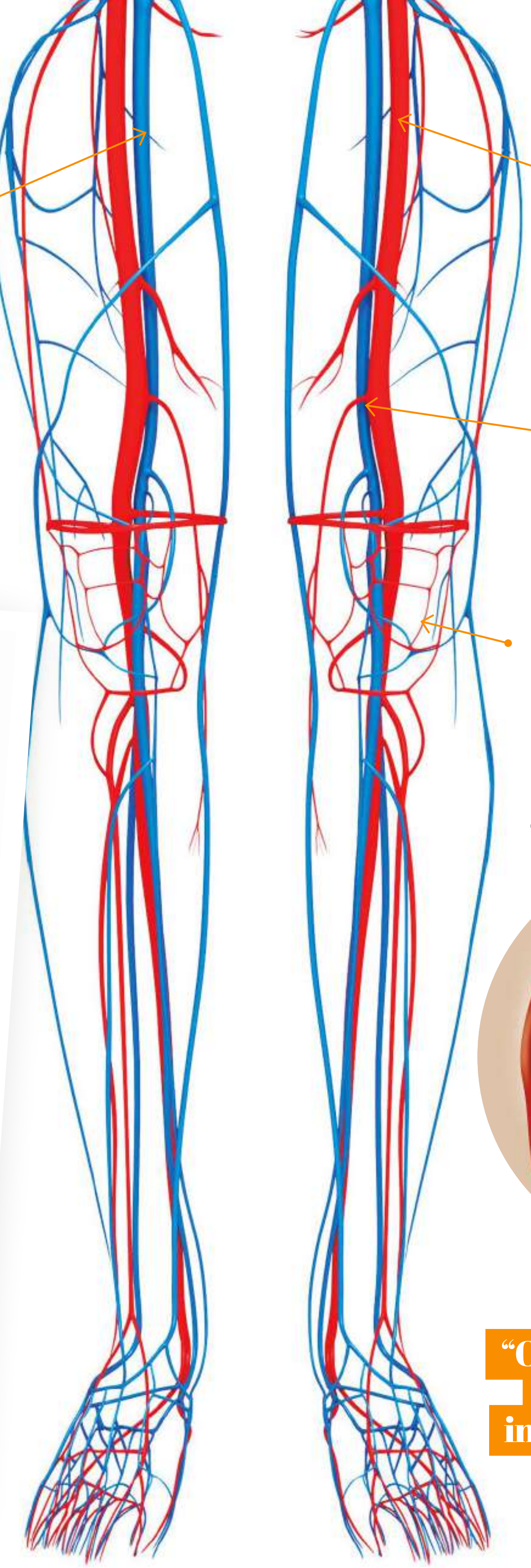
A growing foetus relies on blood exchange with its parent for oxygen and nutrients

TYPES OF BLOOD VESSELS

For blood to efficiently migrate throughout and around the body, it must maintain optimal levels of pressure. Oxygenated blood from the left side of the heart is pumped out at high pressure, so arteries must be able to withstand and maintain this force. They withstand pressure by possessing a thick, muscular wall with an outer, middle and inner layer, and they maintain pressure by possessing a narrow lumen – the space that the blood travels through. Elastic arteries, which are found near the heart muscle, possess more elastic tissue in their middle layer. This helps convert the incremental pulses of pressure from heartbeats into a more constant pressure.

Capillaries are also highly pressurised, but on a much smaller scale. Their lumens are very narrow and their cell walls are only one cell thick. In contrast, veins also possess three layers in their walls, but these are much thinner. But their lumens are much wider, yielding lower pressures.

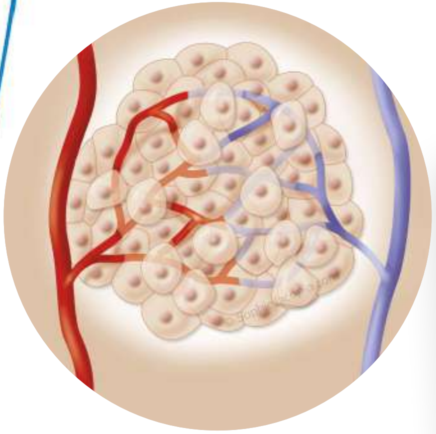




4 INTO THE DEPTHS
The common femoral artery feeds the deep femoral artery that supplies blood to the buttocks, femur and hips, and the superficial femoral artery that supplies the lower leg.

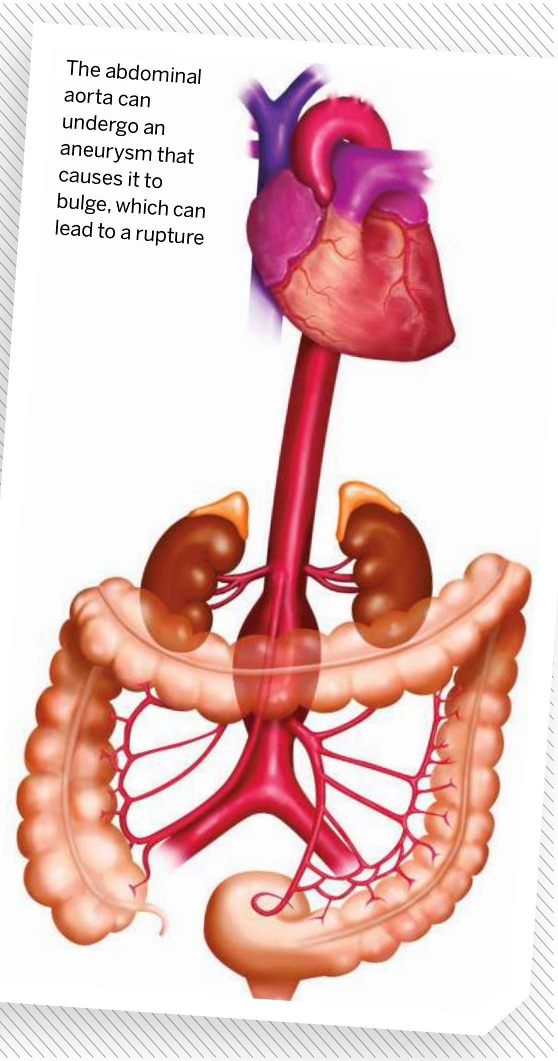
5 BRANCHING PATHS
Blood travels through smaller arteries, into yet smaller arterioles, then into capillaries – the smallest set of blood vessels.

6 NUTRIENTS FOR WASTE
Capillaries are thin enough that oxygen and nutrients can be exchanged for carbon dioxide and waste products between the blood and neighbouring cells. Deoxygenated blood then exits the capillaries into venules.



7 THE RETURN JOURNEY
Smaller venules feed into the major femoral vein, from which blood travels back towards the heart via the inferior vena cava.

> "Our vascular network helps regulate our internal environment"



The abdominal aorta can undergo an aneurysm that causes it to bulge, which can lead to a rupture

© Getty / Alamy / Shutterstock

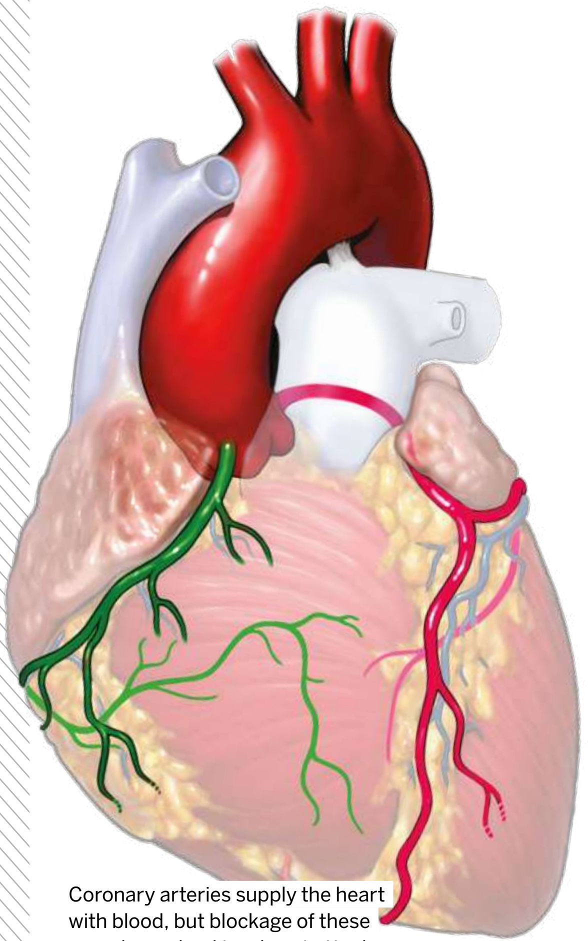
COMMON DISEASES OF BLOOD VESSELS

In the UK, diseases affecting blood vessels are among the biggest killers each year. The cells of our body are so dependent on the oxygen and nutrients supplied by blood that a blockage or rupture in the vascular network can quickly cause catastrophic damage. While some diseases are genetic, many common diseases are caused at least in part by lifestyle choices, such as a poor diet, which results in the bloodstream carrying more harmful compounds than it ideally should. With an increasingly high-fat and sedentary lifestyle, these diseases are growing ever more frequent. Fortunately, however, lifestyle changes and medical innovations are helping to save lives.

Surgery is sometimes necessary to combat blockages and ruptures of the vascular network

Did you know?

Approximately 85 per cent of strokes involve blockages



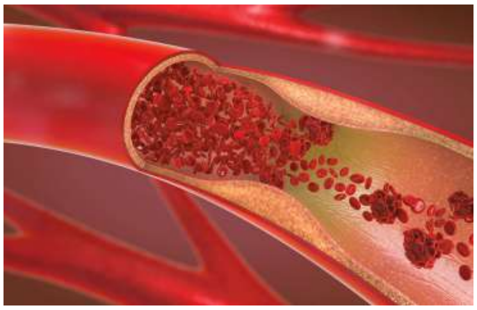
Coronary arteries supply the heart with blood, but blockage of these vessels can lead to a heart attack

CORONARY ARTERY DISEASE

Just like all other muscles in our body, the heart requires a supply of blood to fuel itself. However, rather than gaining nutrients and oxygen from oxygenated blood pumped in and out of its internal chambers, the heart muscle relies on coronary arteries wrapped around its exterior for its blood supply. Over time, components transported by the blood such as cholesterol can stick to the walls of coronary arteries, initiating blockages that can partially or completely block the blood supply to parts of the heart. This process is known as atherosclerosis and can result in angina, which is chest pain caused by an insufficient blood supply to the heart. If the coronary arteries are fully blocked, however, cell death of part of the heart can occur, causing a heart attack. Coronary artery disease can be treated using bypass graft surgery, where arteries are rerouted to supply the regions of the heart cut off by coronary artery blockages.

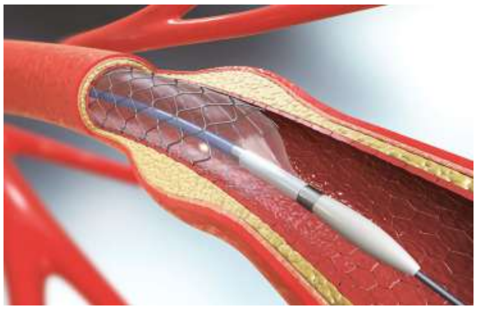
FIXING VESSELS

An angioplasty uses inflated tubes to salvage obstructed arteries



BEFORE

Cholesterol floating in the bloodstream becomes attached to the wall of the artery, drawing fats and causing inflammation. This results in the formation of a plaque which narrows the artery.

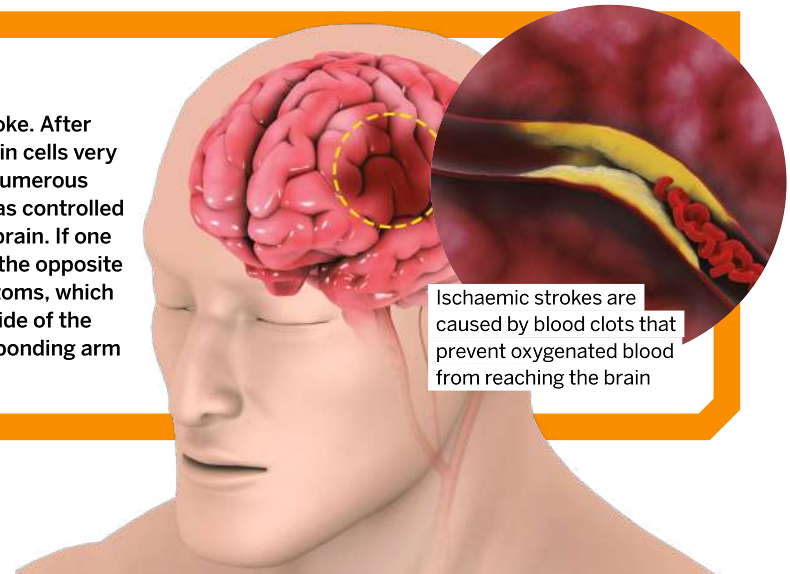


AFTER

A thin catheter is threaded through the artery towards the plaque buildup. A balloon at the catheter's tip is then inflated, pressing a mesh wire against the plaque, forcing it outwards and widening the artery.

STROKE

Atherosclerosis describes the accumulation of plaque on arterial walls. These may originate at various places throughout the body, but can become dislodged and carried elsewhere in the bloodstream. Eventually they can become stuck and cause a blood clot, blocking the artery and preventing blood flow to tissues and organs. If this blood clot occurs in the arteries that feed the brain, it can cause an ischaemic stroke. After being deprived of oxygen, brain cells very swiftly begin to die, causing numerous symptoms relating to the areas controlled by the affected region of the brain. If one side of the brain is damaged, the opposite side of the body shows symptoms, which can include drooping of one side of the face, numbness in the corresponding arm and slurred speech.

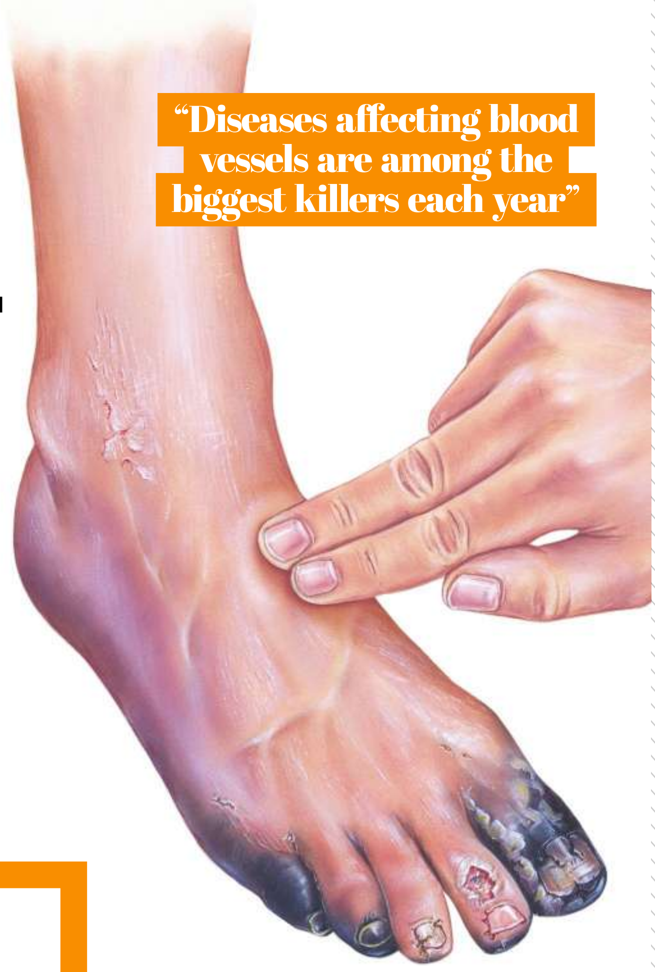


Ischaemic strokes are caused by blood clots that prevent oxygenated blood from reaching the brain

DID YOU KNOW? Blood pressure tests measure pressure in mmHg, or millimetres of mercury

PERIPHERAL ARTERY DISEASE

A narrowing or hardening of artery walls can prove fatal when affecting organs such as the heart or brain, but obstructed arteries feeding the peripheral organs can go unnoticed until the disease is at an advanced stage. Depleted blood flow to the legs can cause symptoms such as cramping, an absence of hair and gangrene that occurs following cell death. Individuals living with diabetes are at particular risk of developing peripheral artery disease due to the abundance of glucose in blood plasma. This interferes with other components in the blood, leading to plaque formation. However, a healthy lifestyle involving regular exercise, not smoking and a low-fat, high-fibre diet can help prevent arterial disease for most adults.

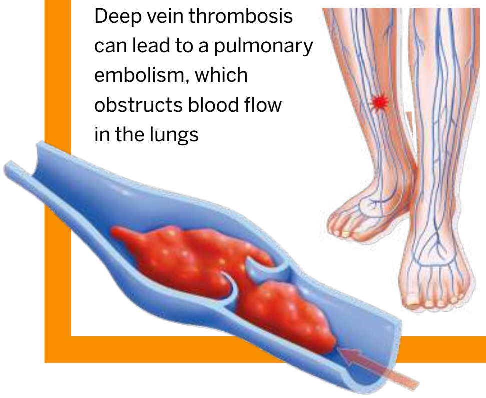


When blood flow is cut off from the feet, cells can begin to die, leading to gangrene

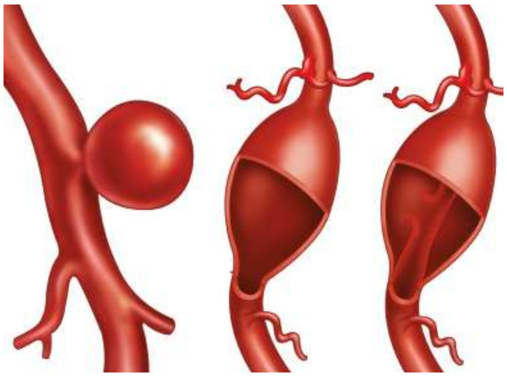
> "Diseases affecting blood vessels are among the biggest killers each year"

DEEP VEIN THROMBOSIS

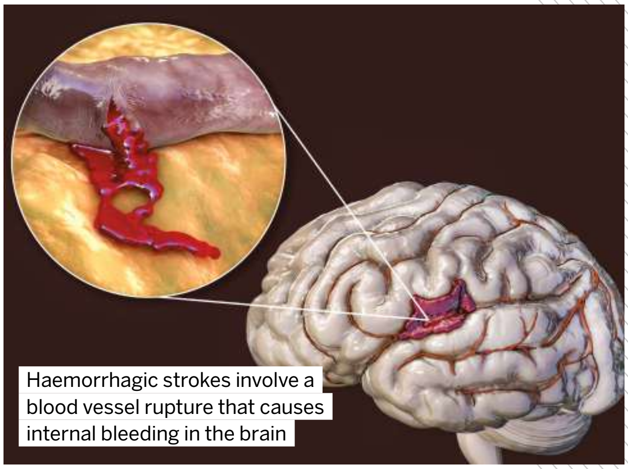
Blood clots can appear rapidly in veins where blood flow is slow and laboured, most common in veins deep in leg muscle. During these cases, such as when a person's legs remain unmoved for long periods, an excess of natural clotting factors in the bloodstream can overstimulate the production of a blood clot. In healthy blood, clots form to prevent bleeding, but during deep vein thrombosis the formed clot can grow to a substantial size – large enough to obstruct blood flow. This can cause pain, swelling and a change in colour of the leg. However, the clot can cause more damage if it travels further through the vascular network into the vessels supplying the lungs, resulting in a pulmonary embolism that can prove fatal.



Deep vein thrombosis can lead to a pulmonary embolism, which obstructs blood flow in the lungs



Blood vessel aneurysms can appear in different forms: secular, with bulges on one side (left); fusiform, with bulges on all sides (centre) or dissect, where blood flows into an internal tear, causing a bulge (right)



Haemorrhagic strokes involve a blood vessel rupture that causes internal bleeding in the brain

8%

Nearly a tenth of your body weight is blood

62,140 MILES

The approximate combined length of blood vessels in the human body

100,000

Estimated deaths from pulmonary embolisms in the US annually

PERITUBULAR CELLS IN THE KIDNEYS CAN DETECT OXYGEN DEFICIENCIES IN THE BLOOD

120/80MMHG

The upper end of healthy blood pressure in an average adult

60 TO 100

Average range of heartbeats per minute in an adult

0.005 MILLIMETRES

The width of your smallest blood vessels are one-tenth that of a hair

THE LIVER RECEIVES THE LARGEST BLOOD SUPPLY WHEN THE BODY IS AT REST

8,000 LITRES

The amount of blood pumped through the vascular network each day

54%

Over half of your blood is found in systemic veins

© Getty / Alamy

In general, a young woman will have a higher blood alcohol level than a young man after drinking the same amount of alcohol

WHY WE GET DRUNK

How does alcohol affect the body?

WORDS **AILSA HARVEY**

Whether you're old enough to enjoy the occasional alcoholic drink yourself or have seen some of the bizarre behavioural effects it can have on other people, it's known that drinking alcohol makes people drunk. But what does this mean? What is it in those glasses, bottles or cans that can alter the control people have over their own bodies? The instigator is an ingredient called ethanol, with the chemical formula C_2H_5OH. Ethanol is produced when yeast ferments the sugars in fruit, grains and vegetables. Different alcoholic products are named based on the source of the alcohol. Gin is made from fermented sugar in grains, such as wheat and barley, vodka uses the sugar from potatoes or grain and wine is made from grapes.

While alcohol is produced on an industrial scale for human consumption, plants also produce alcohol naturally in the wild. Neither are humans the only species that consumes alcohol. Many animals eat fermented foods, becoming drunk both accidentally and on purpose. Each species has evolved to handle its alcohol intake differently. For example, pen-tailed treeshrews have the world's highest alcohol tolerance, allowing them to make use of large quantities of fermented plants as a food source. Humans, meanwhile, can risk serious illness and even death if our limits are not carefully considered. From the fun to the harmful, this is how alcohol makes us drunk.

GOING FROM SOBER TO INEBRIATED

Follow alcohol's journey after it enters the body

1 FIRST ENTRY

As soon as alcohol enters the mouth, some of it enters the bloodstream via blood vessels in the mouth and tongue.

2 INTO THE STOMACH

About 20 per cent of alcohol enters the bloodstream in the stomach. This is a slower process if the stomach is full of food.

3 FINAL ABSORPTION

Any remaining alcohol is absorbed into the bloodstream in the small intestine.

4 BLOODSTREAM

Alcohol travels through your body quickly once it reaches the bloodstream. It can also widen blood vessels, causing body temperature changes.

5 BREAKING DOWN

When the alcohol in the blood reaches the liver, the organ works to break down alcohol into carbon dioxide and water. The liver breaks down one unit of alcohol per hour.

6 EFFECT ON THE BRAIN

Alcohol typically reaches the brain within five minutes and begins to make you feel drunk within ten minutes.

7 FEELING GOOD

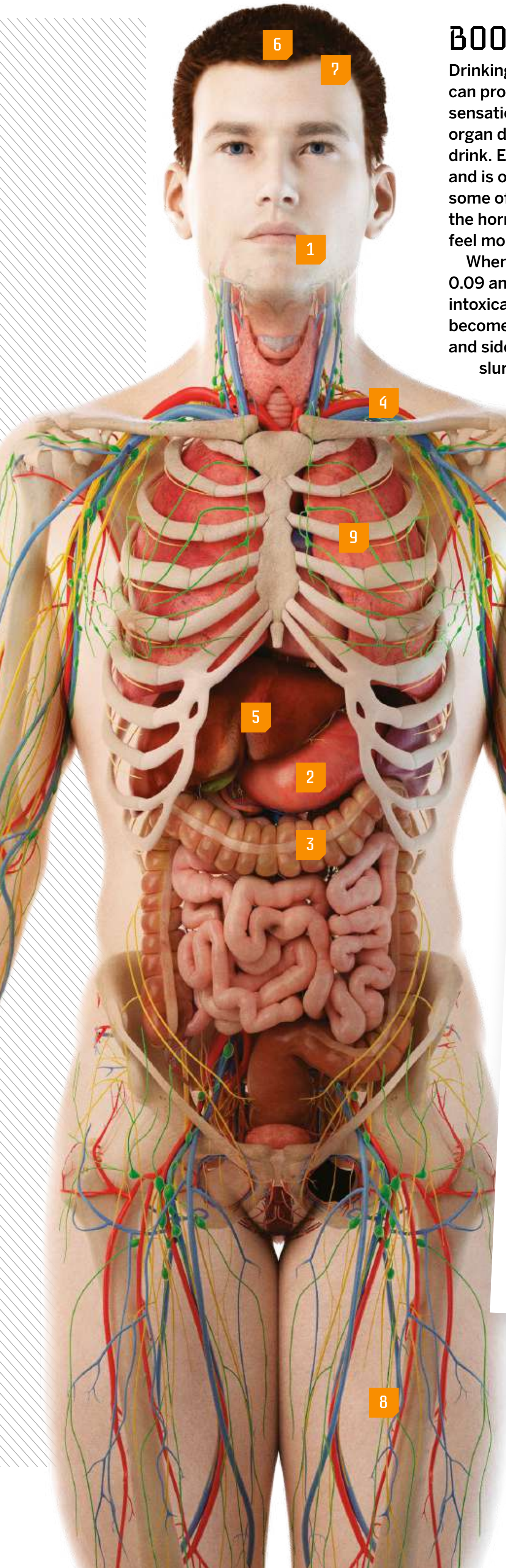
The hormones dopamine and serotonin are released in the brain, often making drunk people feel happy.

8 SLOWING DOWN

When a high volume of alcohol is consumed, the central nervous system's function is slowed, causing loss of coordination and dizziness.

9 BOOZY BREATH

About eight per cent of alcohol evaporates from the blood to the lungs. As it's transferred into the breath, alcohol can be detected by a breathalyser.

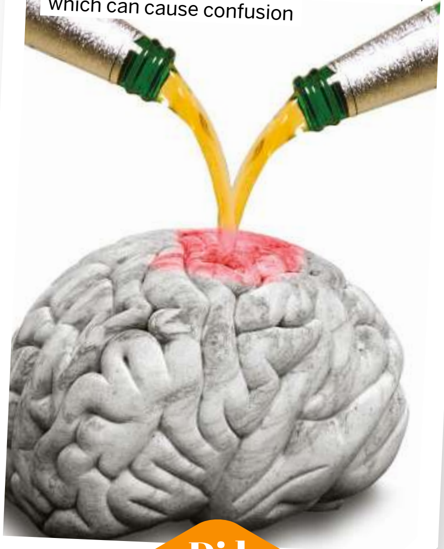


BOOZE ON THE BRAIN

Drinking has a significant impact on the brain and can produce both pleasant and unpleasant sensations. The stages of alcohol's impact on this organ depend on the person and how much they drink. Euphoria is the early stage of feeling drunk, and is one reason drinking is so popular despite some of the negative health impacts. At this stage the hormones released in the brain might make you feel more confident and relaxed.

When your blood alcohol level reaches between 0.09 and 0.25, you're now classed as 'legally intoxicated'. At this stage, a drunk person might become more excitable. The lobes at the front, back and side of the brain are affected and can cause slurred speech or blurred vision. If someone has drunk large volumes of alcohol they can become disorientated, and in some instances lose their short-term memory. This is because the hippocampus – the area of the brain responsible for making new memories – is hindered. The nerves in this area of the brain are slowed down by alcohol. The stages beyond this become more serious and worrying, as the brain will eventually fail to keep vital organs functioning. When a person's blood alcohol level reaches between 0.25 and 0.35, the body is at risk of alcohol poisoning, coma and death.

One of the first areas of the brain to be affected by alcohol is the cerebral cortex, which can cause confusion

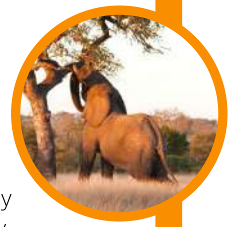


Did you know?

Alcohol can remain in hair follicles for three months

ANIMALS AND ALCOHOL

ELEPHANTS



Elephants don't have the same mutation in the gene ADH7 as humans and many other mammals. This means that despite their size, they can get drunk on relatively small amounts of fermented fruit compared to their body size.

BATS

Egyptian fruit bats like ripe fruit, such as figs and dates. But when they eat foods with over one per cent ethanol, they can become tipsy. Bats have mastered flying drunk. One study showed that New World bats can use echolocation to navigate just as well when drunk.

MONKEYS

Vervet monkeys developed a taste for alcohol after discovering fermented sugar cane. Research discovered that the teenage monkeys got drunk more than adults and one in five monkeys preferred alcoholic water over sugar water.

BEES

Honeybees can become intoxicated after drinking fermented limes and tree sap. In many instances, bees have failed to make their way back to their hives after sipping ethanol. Sometimes those that do return aren't allowed back in.

BIRDS

Berries ferment in winter, which can make the birds that feed on them drunk. The bohemian waxwing is one such species. Most become tipsy but remain in control, but some eat too many alcohol-filled berries can't fly straight.

© Getty / Alamy

Sunscreen comes in many forms, including lotions and aerosol sprays

HOW SUNSCREEN PROTECTS SKIN

Blocking the Sun's harmful rays is important. Here's how sunscreen does the job

WORDS **SCOTT DUTFIELD**

Sunscreen or sunblock is a skincare essential, especially in hot climates. Its goal is to prevent ultraviolet light from penetrating and damaging the skin. Ultraviolet radiation (UV) is emitted by the Sun, and some enters Earth's atmosphere. On its journey to the surface, it will be partially reflected into space by a layer of oxygen called the ozone along with other stratospheric features such as clouds and atmospheric gas. However, the levels of UV that reach the surface are still damaging to our skin.

Health concerns surrounding UV radiation range in severity, from skin ageing and wrinkles to cataract development, immune system suppression and skin cancer. These can affect people with all skin types and colour pigmentations. There are methods that help reduce the level of UV exposure and damage, like wearing a hat, sunglasses and protective clothing. But one surefire way to give your skin the best protection against the Sun is by applying sunscreen.

Inside a bottle of sunscreen are numerous ingredients that can act as a physical barrier against UV radiation, such as zinc oxide or titanium dioxide, reflecting and scattering the UV rays away from the skin. Other ingredients, such as the organic chemical oxybenzone, work to absorb the UV radiation before it can pass into your skin. Components in the sunscreen will then break down over time. The combination of these active ingredients combats UV radiation and prevents it from penetrating the skin.

To measure the risk of sunburn, Toronto-based Environment Canada scientists created the UV index in 1992. The index scores the levels of UV radiation exposure throughout the day from low to very high (1 to 9+). Where the UV index score is 3 or above, UV exposure is strong enough that sunscreen is needed to protect your skin from harm.

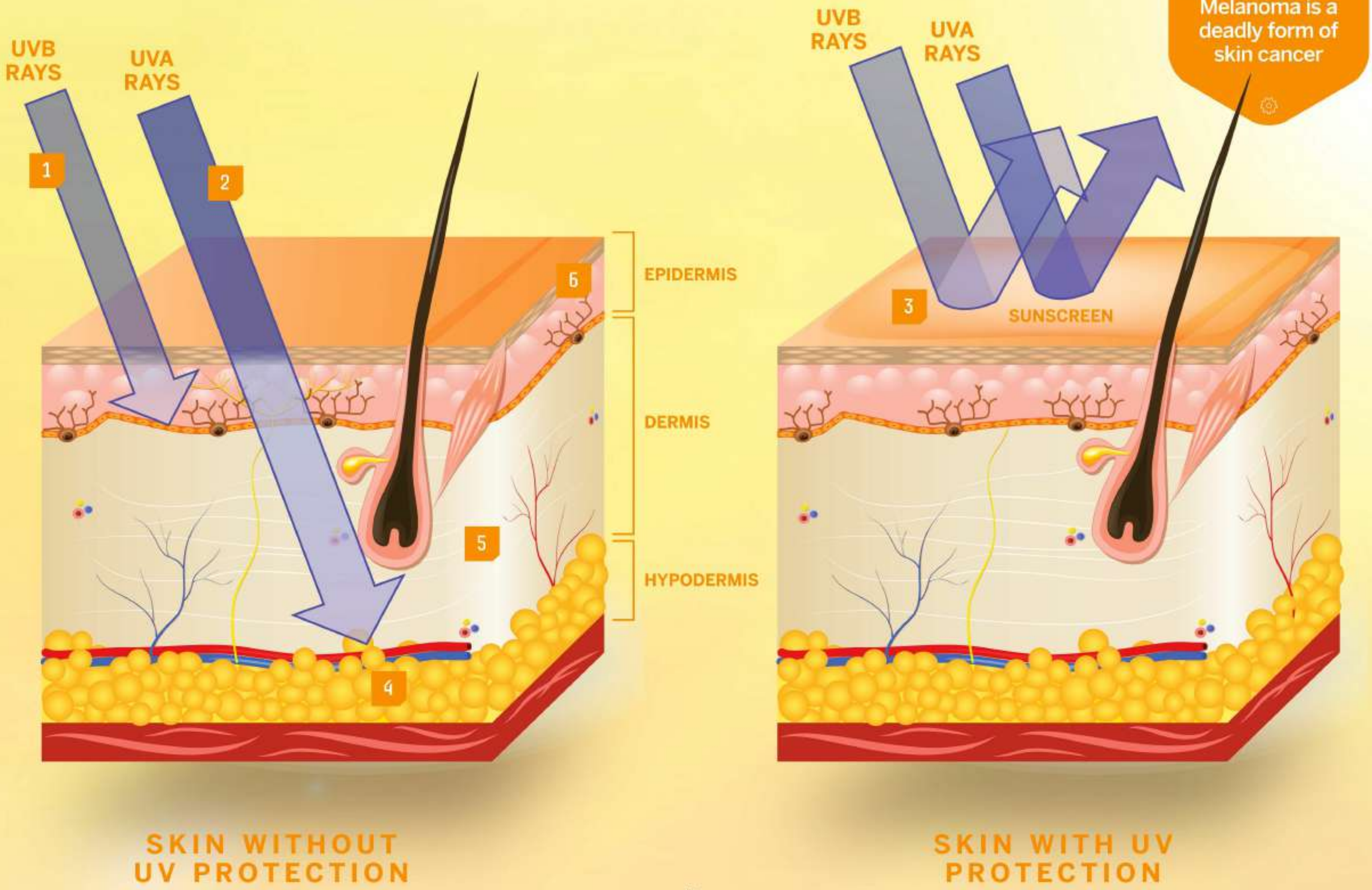
Skin cells that are damaged by sunburn peel away from the body

INSPIRED BY SUNBURN

Throughout history, people have found many different ways to protect themselves from the Sun. The ancient Greeks used olive oil to battle the effects of Sun exposure, while the ancient Egyptians used ingredients such as jasmine and rice bran to block the skin-tanning effects of UV. However, the first modern-day sunscreen was imagined by a Swiss chemistry student called Franz Greiter back in 1938. While climbing the Piz Buin peak of the Alps along the border of Austria and Switzerland, Greiter suffered sunburn, prompting him to create the first sunscreen for UV protection. In 1946 he introduced the world to Gletscher Crème (Glacier Cream) under the brand name Piz Buin. The cream offered people a protection level of SPF 2.

Piz Buin, the Alpine peak where Franz Greiter got sunburn

DID YOU KNOW? Sunscreens with an SPF of at least 30 block 97 per cent of the Sun's rays



SKIN WITHOUT UV PROTECTION

SKIN WITH UV PROTECTION

Did you know?

Melanoma is a deadly form of skin cancer

FIGHTING THE SUN

How sunscreen blocks UV rays from your skin

1 UVB
One of the two basic types of UV radiation is UVB, which is commonly associated with causing sunburn and plays the greatest role in causing skin cancers.

2 UVA
UVA exposure can also lead to the development of skin cancer. It can penetrate the skin deeper than UVB rays and causes wrinkles and skin ageing.

3 BARRIER
Sunscreen acts as a physical barrier against UVB and UVA radiation, preventing them from damaging the cells in different layers of the skin.

4 HYPODERMIS
This is the deepest layer of the skin, containing blood vessels and lipocytes, which are fat-producing cells.

5 DERMIS
Nerves, fibres and collagen can be found in the dermis layer of the skin. This is the deepest layer UVA can penetrate.

6 EPIDERMIS
Both UVB and UVA can penetrate this superficial layer of skin. Here UVB can damage DNA within skin cells, causing them to mutate into cancers.

LEVELS OF PROTECTION

On the front of every sunscreen bottle is its SPF score, which stands for Sun Protection Factor. This score is an indicator of how well a particular sunscreen protects against one type of UV radiation the skin is exposed to, called UVB. The higher the score, the more protection against UVB the sunscreen offers. UVB exposure causes the most damage to your body and can damage cellular DNA, potentially leading to the development of skin cancer. Protection against the other type of UV radiation, called UVA, is not accounted for in SPF scores. However, in the UK sunscreen bottles also have a five-star rating system to gauge UVA protection levels. The NHS recommends the use of sunscreens with an SPF score of 30 or above and at least a four-star rating for UVA protection.

SUN SCREEN
SPF 30
HIGH PROTECTION

© Getty

WHAT IS NATO?

WORDS **JOANNA ELPHICK**

Why the North Atlantic Treaty Organization formed and what it's done since its conception in 1949 to the crisis in Ukraine

DID YOU KNOW? Despite the fact there are currently 30 different NATO member states, there are two official languages: French and English

At the close of World War II, the economic position of Western Europe was fragile and its military sorely depleted. Meanwhile, the communist Soviet Union had grown in size and strength, seizing political control over the states of Central and Eastern Europe and dividing the continent in two. All wartime cooperation ceased, leaving the communists pushing against the West from behind the Iron Curtain. The US was particularly concerned with communist activity, and realising that it would take a group effort to uphold democratic principles initiated a series of covert discussions with its Eastern European allies. It was during this political unrest that NATO was born. Its mission: to ensure peace and security on the international stage. The initial members consisted of Belgium, Canada, Denmark, France, Iceland, Italy, Luxembourg, The Netherlands, Norway, Portugal, the UK and the US. The treaty was signed in Washington DC with US General Dwight Eisenhower being appointed as its first Supreme Allied Commander Europe, or 'SACEUR'. A ministerial representative from each member state was brought together to form the North Atlantic Council, while its Military Committee, composed of military chiefs from the member states, was split up into two groups: Allied Command Operations and Allied Command Transformation.

Over the years, NATO has expanded and evolved, altering its job description to meet the world's needs, from combating cyber warfare to the threat of terrorism. However, the original mission to maintain peace wherever possible remains the number-one priority of today's 30 member states. NATO's primary objective will always be to promote a productive dialogue, but if such talks break down, it will step in to 'manage' conflicts. Its first military operation occurred in 1995 when NATO launched a series of air strikes against the Bosnian Serb position in Sarajevo. This led to the Dayton Agreement, which resulted in peace talks and mutual respect. Further conflicts followed across Yugoslavia, Afghanistan and more recently Libya. But what of Ukraine? Though Ukraine has flirted with the notion of joining NATO for many years, signing the NATO-Ukraine Charter in 1997 and supporting NATO's 2013 anti-piracy mission in the Indian Ocean, they remained close with Russia. Since Russia and its NATO equivalent, the Collective Security Treaty Organization (CSTO), have always regarded NATO with mistrust, it became difficult for Ukraine to join.

When Viktor Yanukovych became president of Ukraine in 2010, he made the decision to shun NATO, preferring to bolster a close connection with Russia. Today's Ukrainian president, Volodymyr Zelensky, feels differently. Russian troops have bombed his cities with hypersonic Kinzhal missiles and taken over the Chernobyl power plant, causing a potential disaster not only for Ukraine, but the entire continent. NATO has once again offered support, providing humanitarian aid and training Ukrainian civilians on how to protect themselves in war. However, NATO is wary regarding further involvement since it fears the presence of its troops may escalate the situation, causing a full-blown war between Russia and the West. Instead it has increased NATO troops along the member state borders.

Did you know?

NATO has its headquarters in Brussels, Belgium

NATO allies US president Joe Biden and Andrzej Duda, the president of Poland, met to discuss how they can support Ukraine during its war

NATO
CLOSE THE SKY
Ukrainian soldier
defends Your sky

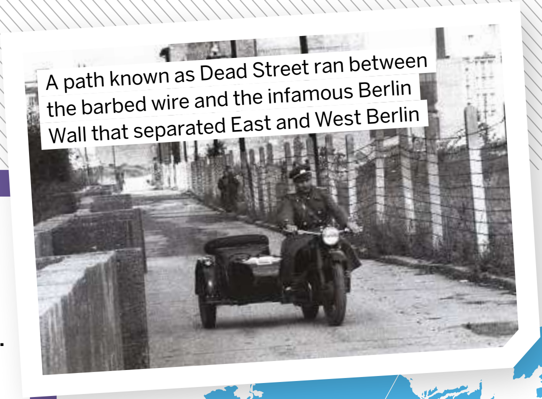
During a protest of solidarity with Ukraine in Poland, many individuals begged NATO to 'close the sky' against the Russian planes over Ukraine

Russian minister of defence Anatoly Serdyukov met with his CSTO in Bishkek, the capital of Kyrgyzstan, during a summit meeting in 2007

MIRROR ORGANISATION

The Collective Security Treaty Organization (CSTO) grew from the ashes of the dissolved Soviet Union and was signed in 1992, ultimately coming into effect in April 1994. It currently boasts six members: Russia, Armenia, Belarus, Kazakhstan, Kyrgyzstan and Tajikistan. As with NATO, CSTO has attempted to band together with like-minded countries in order to share military force, equipment and general support with the notion that there is safety in numbers. Although far smaller, CSTO mirrors Article 5 of NATO, offering a collective mutual defence system, reinforcing the belief that it's the Eurasian counterpart of NATO. By the 2000s it had expanded, culminating with a Rapid Response Force in 2009.

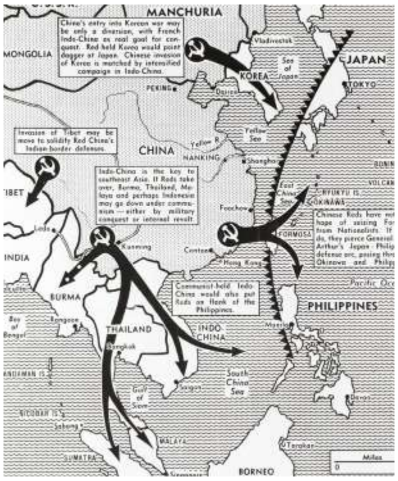
© Getty / Alamy



A path known as Dead Street ran between the barbed wire and the infamous Berlin Wall that separated East and West Berlin

THE COLD WAR

The Soviet Union and the US started an arms race shortly after the end of WWII that continued for over 40 years. Unlike the World Wars, the Cold War was never fought openly. Instead it consisted of a drawn-out battle of wills between the ideologies of the communist East and the capitalist West. The US adopted its 'Containment Strategy' whereby it attempted to suppress communist ideas so that they couldn't spread to other neighbouring countries. Propaganda and espionage were used by both sides, resulting in a prolonged period of mistrust and paranoia. A communist coup in 1948 across Czechoslovakia, closely followed by a blockade of capitalist West Berlin, instigated a flurry of activity from US allies, resulting in the North Atlantic Treaty Organization. The USSR responded by forming its own allied forces signed under the Warsaw Pact, creating a distinct line between the opposing ideological factions commonly known as the Iron Curtain.


MANCHURIA
China's entry into Korean war may be only a diversion, with French Indo-China as real goal for conquest. Red held Korea would point dagger at Japan. Chinese invasion of Korea is matched by intensified campaign in Indo-China.
MONGOLIA
Vladivostok
Sea of Japan
JAPAN
KOREA
TOKYO
PEKING
Dairen
Invasion of Tibet may be move to solidify Red China's Indian border defenses.
CHINA
Yellow R.
Yellow Sea
NANKING
Shanghai
Indo-China is the key to southeast Asia. If Reds take over, Burma, Thailand, Malaya and perhaps Indonesia may go down under communism — either by military conquest or internal revolt.
East China Sea
RYUKYU IS.
OKINAWA
Foochow
FORMOSA
Kunming
Canton
Hong Kong
INDIA
Communist-held Indo-China would also put Reds on flank of the Philippines.
PHILIPPINES
Pacific Ocean
BURMA
Bay of Bengal
Rangoon
THAILAND
Bangkok
INDO CHINA
Manila
Saigon
South China Sea
Gulf of Siam
ANDAMAN IS.
NICOBAR IS.
Sabang
MALAYA
SUMATRA
Tarakan
BORNEO
Miles
0

A map from 1950 highlights the US fear that if one country became a communist base, it would start a chain reaction of communist ideologies

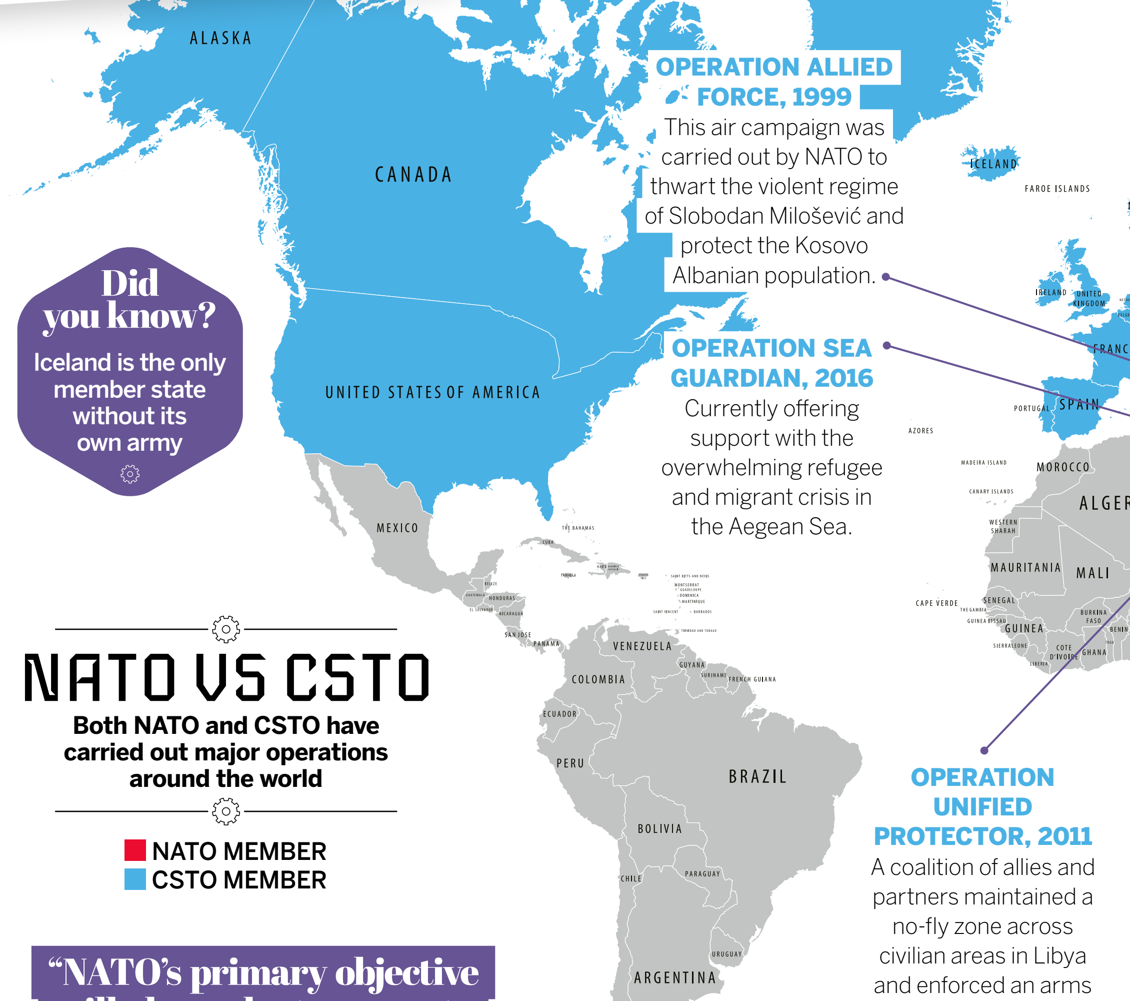
Did you know?

Iceland is the only member state without its own army

NATO VS CSTO

Both NATO and CSTO have carried out major operations around the world

🟥 NATO MEMBER
🟦 CSTO MEMBER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ALASKA
CANADA
ICELAND
FAROE ISLANDS
IRELAND
UNITED KINGDOM
FRANC
PORTUGAL
SPAIN
AZORES
MADEIRA ISLAND
MOROCCO
CANARY ISLANDS
WESTERN SAHARA
ALGER
MAURITANIA
MALI
CAPE VERDE
SENEGAL
THE GAMBIA
GUINEA BISSAU
GUINEA
SIERRA LEONE
LIBERIA
COTE D'IVOIRE
GHANA
BURKINA FASO
BENIN
UNITED STATES OF AMERICA
MEXICO
THE BAHAMAS
CUBA
SAN JOSE
PANAMA
VENEZUELA
GUYANA
SURINAME
FRENCH GUIANA
COLOMBIA
ECUADOR
PERU
BRAZIL
BOLIVIA
CHILE
PARAGUAY
URUGUAY
ARGENTINA

OPERATION ALLIED FORCE, 1999

This air campaign was carried out by NATO to thwart the violent regime of Slobodan Milošević and protect the Kosovo Albanian population.

OPERATION SEA GUARDIAN, 2016

Currently offering support with the overwhelming refugee and migrant crisis in the Aegean Sea.

OPERATION UNIFIED PROTECTOR, 2011

A coalition of allies and partners maintained a no-fly zone across civilian areas in Libya and enforced an arms embargo while toppling its ruler Muammar Gaddafi.

> "NATO's primary objective will always be to promote a productive dialogue"

NATO THROUGH TIME

1949
NATO was created by the US, Canada and a number of Western European countries.

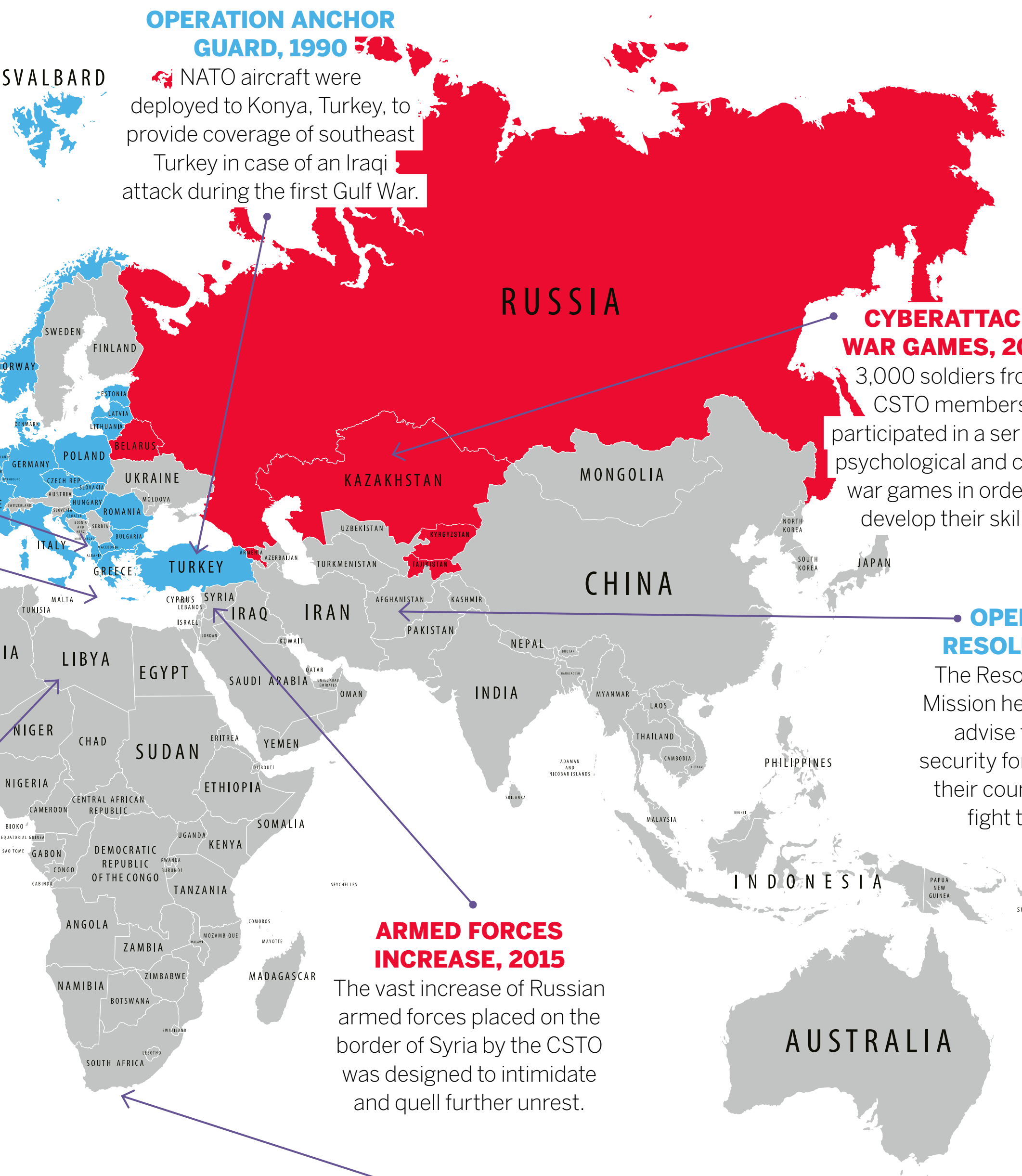
1956
While dealing with the Suez Crisis, NATO decided to develop its political role.

1966
Under Charles de Gaulle's leadership, France decided to withdraw from NATO's integrated military structure.

1967
Nuclear weapons were integrated into NATO's force structure, thereby developing a strategy of 'flexible response'.

1974
NATO incorporated economic factors into its general security concept.

DID YOU KNOW? Article 5, which lies at the heart of NATO, has been invoked only once


SVALBARD
SWEDEN
FINLAND
NORWAY
ESTONIA
LATVIA
LITHUANIA
DENMARK
BELARUS
POLAND
GERMANY
CZECH REP.
SLOVAKIA
AUSTRIA
HUNGARY
UKRAINE
MOLDOVA
ROMANIA
SERBIA
BULGARIA
ITALY
GREECE
TURKEY
RUSSIA
KAZAKHSTAN
MONGOLIA
UZBEKISTAN
KYRGYZSTAN
TAJIKISTAN
TURKMENISTAN
AZERBAIJAN
ARMENIA
NORTH KOREA
SOUTH KOREA
JAPAN
CHINA
AFGHANISTAN
KASHMIR
PAKISTAN
NEPAL
INDIA
IRAN
IRAQ
SYRIA
CYPRUS
LEBANON
ISRAEL
JORDAN
KUWAIT
QATAR
UNITED ARAB EMIRATES
OMAN
SAUDI ARABIA
YEMEN
MALTA
TUNISIA
LIBYA
EGYPT
NIGER
CHAD
SUDAN
ERITREA
DJIBOUTI
ETHIOPIA
SOMALIA
NIGERIA
CENTRAL AFRICAN REPUBLIC
CAMEROON
EQUATORIAL GUINEA
SAO TOME
GABON
CONGO
DEMOCRATIC REPUBLIC OF THE CONGO
UGANDA
KENYA
RWANDA
BURUNDI
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ANGOLA
ZAMBIA
MALAWI
MOZAMBIQUE
COMOROS
MAYOTTE
ZIMBABWE
NAMIBIA
BOTSWANA
MADAGASCAR
SWAZILAND
LESOTHO
SOUTH AFRICA
BHUTAN
BANGLADESH
MYANMAR
LAOS
THAILAND
CAMBODIA
VIETNAM
ANDAMAN AND NICOBAR ISLANDS
SRI LANKA
PHILIPPINES
MALAYSIA
BRUNEI
INDONESIA
PAPUA NEW GUINEA
SOLOMON ISLANDS
VANUATU
FIJI
NEW CALEDONIA
AUSTRALIA
TASMANIA
NEW ZEALAND

OPERATION ANCHOR GUARD, 1990

NATO aircraft were deployed to Konya, Turkey, to provide coverage of southeast Turkey in case of an Iraqi attack during the first Gulf War.

CYBERATTACK WAR GAMES, 2014

3,000 soldiers from CSTO members participated in a series of psychological and cyber war games in order to develop their skills.

OPERATION RESOLUTE, 2015

The Resolute Support Mission helped train and advise the Afghan security forces to protect their country and help fight terrorism.

ARMED FORCES INCREASE, 2015

The vast increase of Russian armed forces placed on the border of Syria by the CSTO was designed to intimidate and quell further unrest.

OPERATION OCEAN SHIELD, 2009

This contributed to international efforts to stop piracy and to ensure humanitarian aid reaches its destination safely.

In 2010, the National Bolshevik Party set fire to the NATO flag during a protest march in Moscow

5 KEY NATO ARTICLES

1 ARTICLE 2
This article focuses on NATO'S overwhelming desire to bring about security and wellbeing to all its parties through a strengthening of their individual economic situations.

2 ARTICLE 4
This article looks to emphasise NATO's wish to support other members in their bid for territorial integrity and political independence.

3 ARTICLE 5
Arguably the most important article, it ensures that an attack on one of the parties will be viewed as an attack on all the parties. This results in a banding together of all NATO countries.

4 ARTICLE 6 (1)
This clarifies where Article 5 can be applied, including all relevant territories and their accompanying jurisdictions, their aircraft and sea vessels.

5 ARTICLE 9
This set up a council represented by each party member to promptly deal with any issue as and when it arises. It also established a corresponding defence committee.

1985
Soviet leader Mikhail Gorbachev initiated a process of reform in the Soviet Union, allowing freely elected administrations in Eastern Europe.

1991
NATO adapted its military doctrine and began working closely with 'partner countries'.

1994
NATO launched its Partnership for Peace program.

2001
Article 5 of the treaty was invoked for the first time in reaction to the 9/11 terrorist attacks in America.

2022
After an emergency summit meeting, NATO decided to provide Ukraine with special kits to protect from nuclear and chemical attacks.

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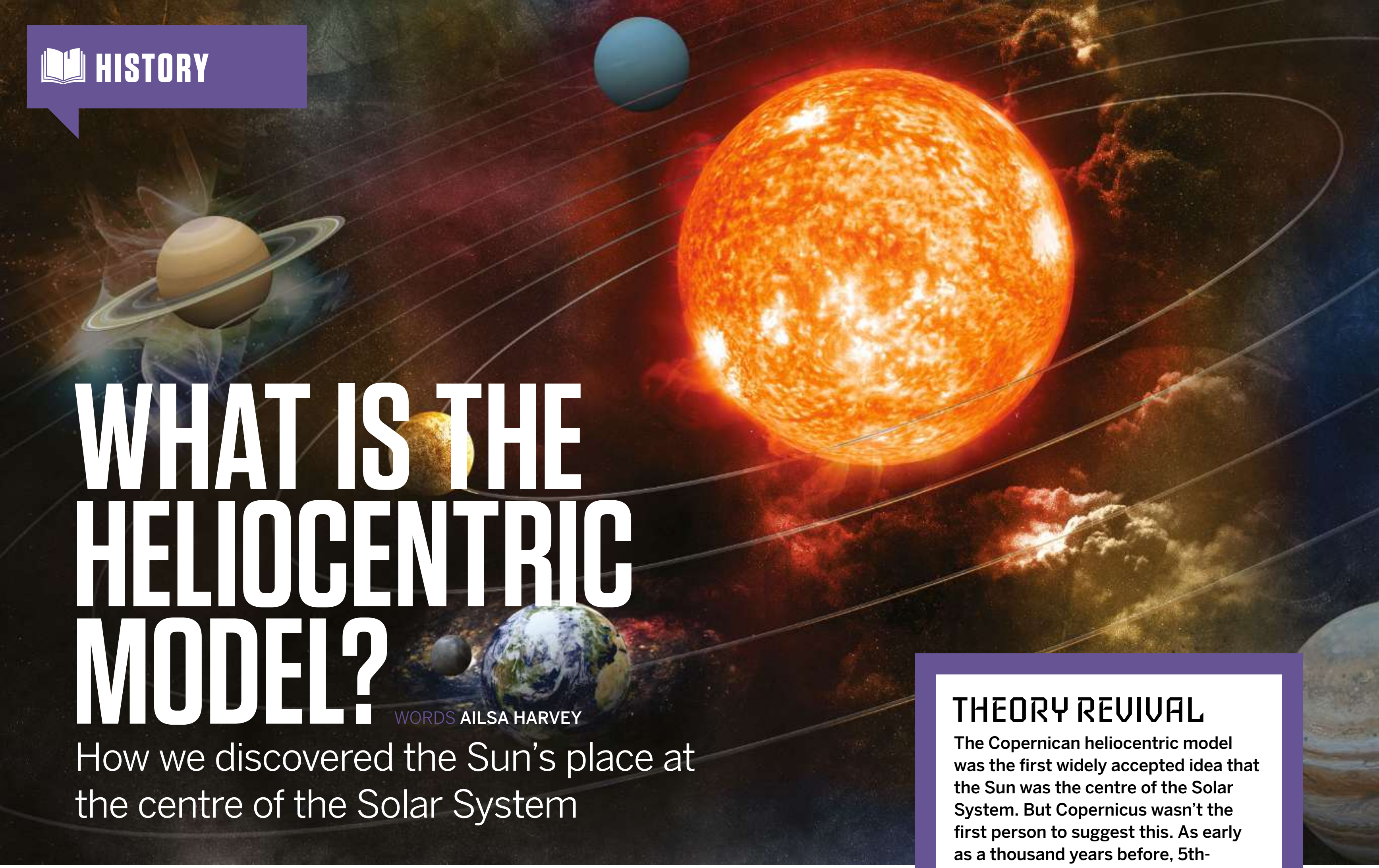


WHAT IS THE HELIOCENTRIC MODEL?

WORDS **AILSA HARVEY**

How we discovered the Sun's place at the centre of the Solar System

Where are we in the universe? It's a simple question when analysing our immediate cosmic whereabouts, but how did astronomers learn of our position in the Solar System? Today we know that Earth and the other planets surrounding us are all in orbit around the Sun. However, it was once believed that Earth was at the centre of what was thought to be the entire universe, and that everything revolved around us. This is now known as the geocentric model, while the heliocentric model puts the Sun rightly at the centre. Nicolaus Copernicus proposed the heliocentric model in his work published in 1543. While his theory of the Sun being central was correct, the model in its entirety held many inaccuracies. Because the heliocentric model was initially pieced together before telescopes existed, all observations had to be made with the naked eye and simple instruments. The positions of planets were predicted largely by observing their position and size against the stars.

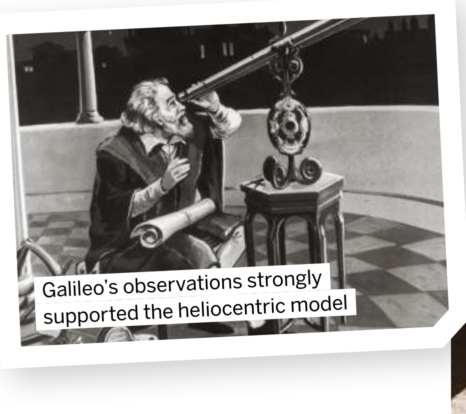
Did you know?

The Catholic Church was strongly against the theory

WHY WAS THIS MODEL SO IMPORTANT?

By answering the question of what was at the centre of the Solar System, astronomers were able to find the answers to other questions too. Mercury and Venus' orbits were placed between the Sun and Earth, revealing to astronomers why they appeared so different in size and shape over time. When the planets were on the far side of the Sun relative to the position of Earth, the bodies appeared much smaller in the sky. When on one side of the Sun, the light hitting the planets gave them a crescent shape to observers.

Almost a century after Copernicus' theory was released, scientists such as Johannes Kepler, Galileo Galilei and Isaac Newton were able to use the heliocentric model to make new findings. Kepler and Newton worked out precise measurements of the planets' movements around the Sun, while Galileo used his telescope to prove heliocentrism.

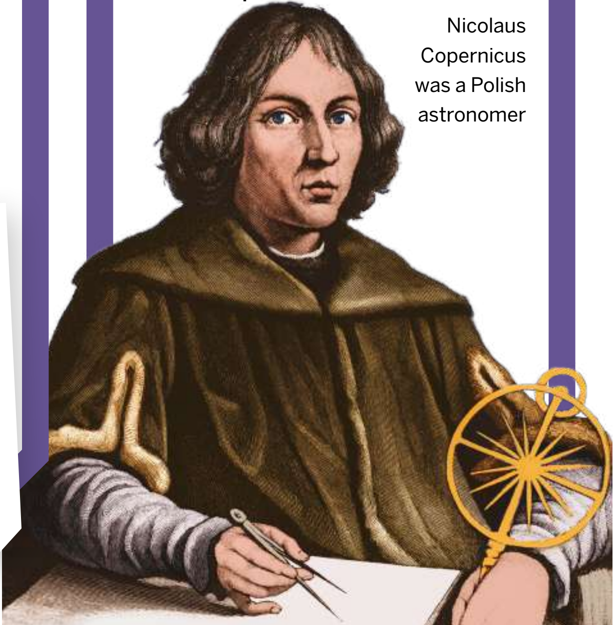


Galileo's observations strongly supported the heliocentric model

THEORY REVIVAL

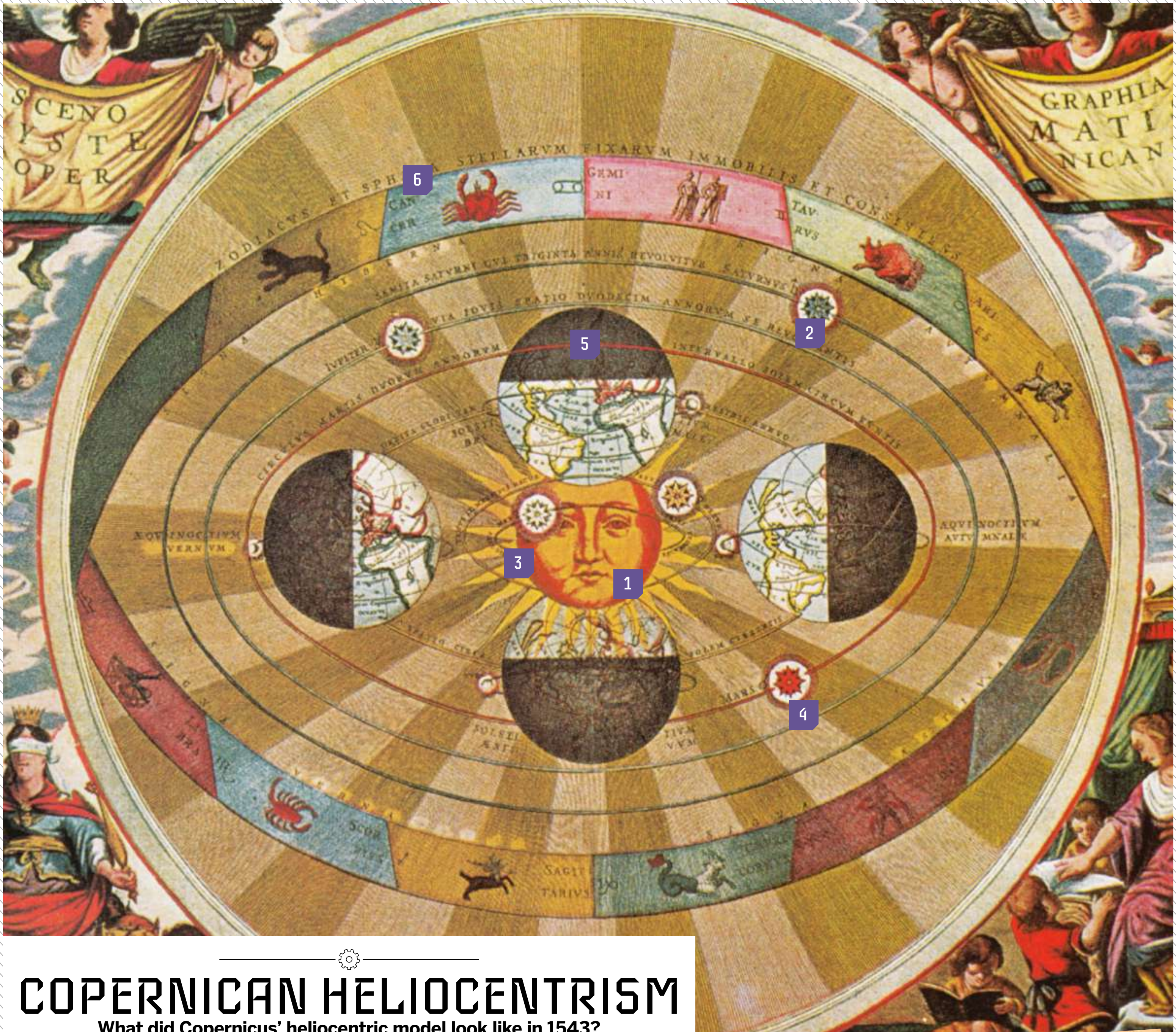
The Copernican heliocentric model was the first widely accepted idea that the Sun was the centre of the Solar System. But Copernicus wasn't the first person to suggest this. As early as a thousand years before, 5th-century Greek philosophers Philolaus and Hicetas suggested that the Earth could be circling a fiery object. Greek astronomer Aristarchus of Samos suggested that this object was the Sun two centuries later.

Because no one was able to explain why the stars looked the same despite Earth changing position, the geocentric model became more widely recognised. Egyptian astronomer and mathematician Claudius Ptolemy overcame this problem with a new theory – that Earth was fixed at the centre of the Solar System. This theory remained popular for around 1,400 years, which made the revival of the heliocentric model seem like a new concept.



Nicolaus Copernicus was a Polish astronomer

DID YOU KNOW? 16th-century Italian scientist Giordano Bruno was burned at the stake for teaching heliocentrism



COPERNICAN HELIOCENTRISM

What did Copernicus' heliocentric model look like in 1543?

1 STATIC SUN
Copernicus thought that the Sun was stationary in its central position.

2 ORBITING SPEED
In the original heliocentric model, the planets orbited the Sun at the same speed.

3 CENTRAL SUN
Copernicus placed the Sun close to the centre of the universe, but not at the exact centre.

4 PLANET ORDER
According to this model, the planet order is Mercury, Venus, Earth, Mars, Jupiter, Saturn and the stars.

5 ROCKY EARTH
In previous models, people believed that the other planets were made of entirely different materials to Earth. The heliocentric model helped scientists realise Earth was more like the other planets.

6 FIXED STARS
In this model, the stars don't move. They appear to move in the opposite direction due to Earth's rotation.

Nicolaus Copernicus' published heliocentric model

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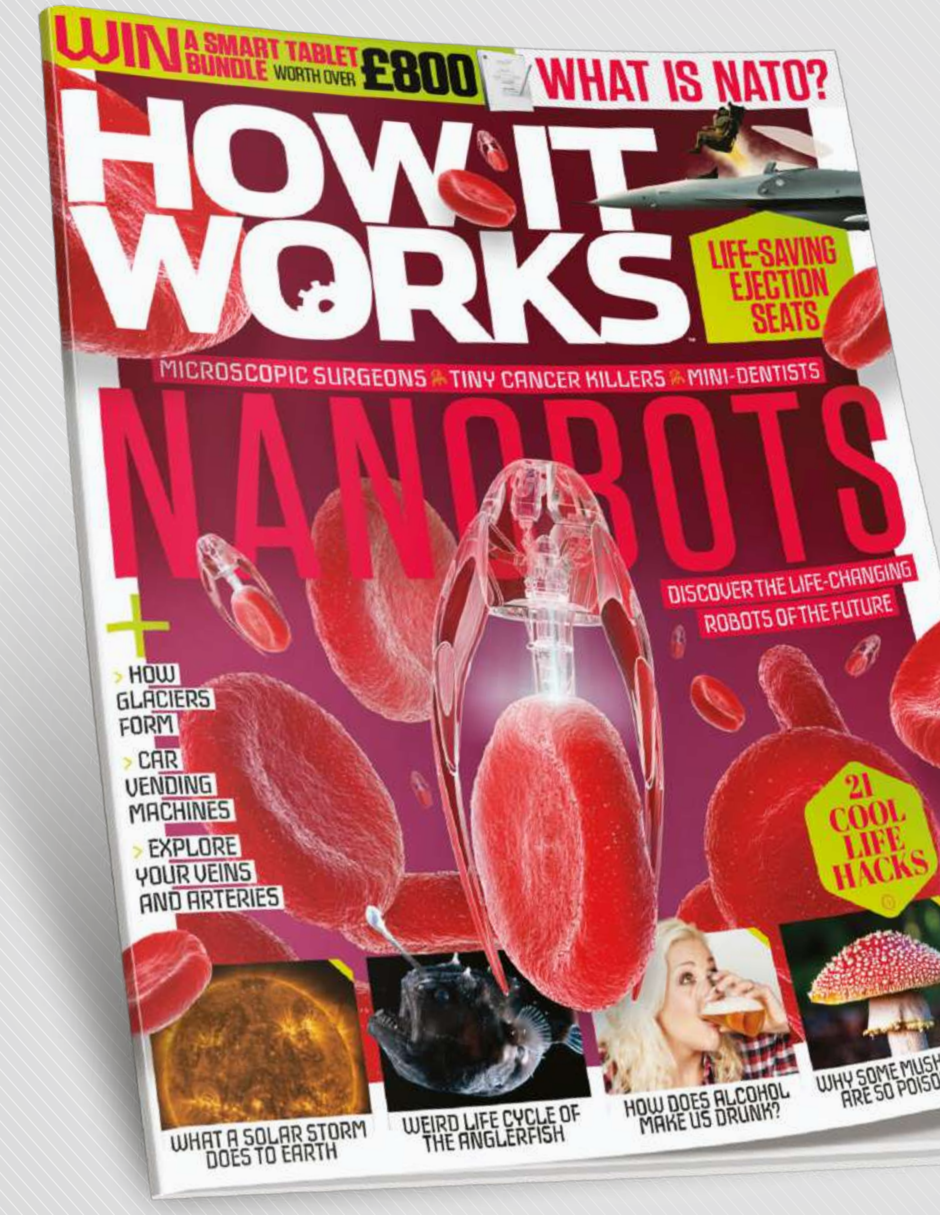
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BRAINDUMP

Amazing answers to your curious questions

How do fire breathers not burn themselves?

Harry Sanders

Preparation is key to the art of fire breathing, and only through keeping safety in mind at all times can even the most gifted fire breather perform uninjured. To do this, they focus on three main things: fuel type, technique and wind direction. The first is arguably the most important factor, as if a fuel with a low flash point is chosen, such as alcohol, it becomes incredibly difficult to control the resulting flame, as the substance will be highly volatile at low temperatures. Instead fire breathers will use a substance like paraffin, which has a relatively safe flash point. Secondly, fire breathers will have honed their technique of inhaling the substance, adding a small amount of it in liquid form to their mouth and then breathing the resultant vapour or liquid over their energy source, usually a lit torch. Fire breathers will always take note of wind direction at all times in order to remove the possibility of having the resultant flame blown back over them.

Did you know?

Wood fires burn at around 6,000 degrees Celsius

WHAT ARE BUTTERFLIES' WINGS MADE OF?

Dorothy Burns

Butterflies are from the order of insects known as Lepidoptera. A butterfly has four wings – two forewings and two hindwings. Each wing is made up of thousands of tiny scales that sit in overlapping rows over a framework of veins – a bit like tiles on the roof of a house. Some scales contain colour pigments, whereas others are translucent, creating colour by refracting and diffusing light.

The front and back of the wings usually have different patterns. The undersides are often designed to help the butterfly camouflage to its surroundings when it's resting – like the mottled leafy green on the orange-tip – and butterflies rest with their wings closed. If you see a butterfly sitting with its wings open, it will be absorbing sunlight to raise its body temperature. Peacock butterflies use the eye patterns on their wings to scare off predators when they are basking.

Butterfly wings are very delicate and often tear, but it takes a lot of damage to stop them from flying. Scales containing colour pigment can also fade in sunlight. If a butterfly looks pale, it could mean it's nearing the end of its life. Sometimes the pigments mutate, causing rare variations to occur like copper butterflies with white wings instead of orange ones. There are often ultraviolet patterns in the wings that we cannot see, but which may possibly be seen by other butterflies.

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Don't forget

WHAT IS A MEMORY?

Kirsty Stockton

Memory is the brain's ability to recall the past. It generally falls into three categories: sensory, short term and long term. Look at this page, close your eyes and try to remember what it looks like. Your ability to recall what this page looks like is an example of your sensory memory. Whether or not this page is important to you will determine how likely it is that it will get passed on to your short-term memory.

Can you remember the last thing you did before reading this? That's your short-term memory, and is a bit like a temporary storage facility where the less important stuff can decay over time. But more important stuff can end up in the long-term memory. Our senses are constantly being bombarded with information. Electrical and chemical signals travel from our eyes, ears, nose, touch and taste receptors and the brain then makes sense of these signals. When we remember something, our brain refires the same neural pathways along which the original information travelled. In this way, you are almost reliving the experience by remembering it.

WHAT IS LOVE, AND WHAT TRIGGERS IT?

Annie Lyonhart

Love is the emotion of strong affection and personal attachment. Love comes in many forms, varying from the generic and platonic type – such as 'I love that film' and 'I love my friends' – to the more personal, intense romantic love. Love is seen as a mammalian drive similar to hunger or thirst, as it activates the same area of the brain as these cravings. It is speculated that romantic love evolved to enable us to focus our mating energy on one partner long enough to stay together and rear young.

There are many different triggers for love: specific chemicals being released in the brain, meeting someone who you are compatible with and so on. As long as we are surrounded by other people, it would be near impossible to prevent love from eventually happening in some way or another.

There are different types of love

Did you know?
Owls have three eyelids to prevent damage to the eyes

HOW DO OWLS TURN THEIR HEADS AROUND?

Alison Whitman

With 14 vertebrae in the neck – twice that of a human – an owl has more flexibility and can turn its head through 270 degrees without moving its body. This adaptation is necessary because owls' eyes are almost completely fixed in their sockets. Being able to move the head allows an owl to focus its vision and hearing towards its prey, often with deadly results.

Astronauts wear sealed spacesuits for safety

How long could a human survive unprotected in outer space?

Sam Barnes

You might be able to survive in space for over a minute, so long as you got back to safety and medical care immediately after. Following a sudden exposure to the vacuum of space, the first thing to do would be breathe out – if you held your breath, the gas expanding in your lungs due to the reduced external pressure would cause them to rupture. Around ten seconds in, you'd start to lose consciousness and vision due to oxygen depletion. In the low-pressure environment, your body fluids would begin to vaporise, causing tissue to swell up. If you were in sunlight without the protective effect of Earth's atmosphere, serious sunburn would occur. Training accidents suggest that if astronauts are returned into a pressurised oxygen environment within 90 seconds, injuries are reversible. But with so many factors at play, the survival limits are not well known.

© Getty

WHAT'S THE FARTHEST INTO SPACE WE'VE SEEN?

James Davison

The most distant observed object is HD1, a galaxy candidate identified in April 2022. The light we're seeing from this object has been travelling through the universe for about 13.5 billion years, yet we are seeing the object as it was when the light left it and began its journey to Earth. In the 13.5 billion years that the photons of light given off by HD1 have been travelling, that distance has stretched, giving a proper distance of approximately 33.4 billion light years. As a result, the light itself has become stretched, which causes it to be shifted more towards the red end of the spectrum, or redshifted. The farther you look out into space, the farther back in time you'll see. This is because light has a finite speed of around 186,000 miles a second. Although it travels extremely fast, it still takes time for light to travel across vast distances in the universe. Because of this, there's a limit to what we can see. It also means there are regions of space we will never see because they are so far away – even though the light is travelling towards us, the space between us and the most distant objects is expanding faster.

We calculate the age of the universe to be around 13.8 billion years old, so we can only see light that has been travelling for this amount of time. However, the rate of expansion of the universe has been changing.

Did you know?

Humans have 33 vertebrae and 24 ribs

Exercise can cause a sharp pain in the side

Why do we get a stitch?

Simon Walsh

There are many theories about what causes that horrible side pain we commonly know as a stitch, but almost all the theories point towards the diaphragm as the main cause. The diaphragm is a sheet of muscle that sits below the rib cage and plays a big part in respiration. Attached to the diaphragm are various ligaments that connect to different organs, one of which is the liver. It's thought that as you exercise, the liver moves around – as does the diaphragm due to breathing. This movement causes the connecting ligaments to stretch, giving rise to a sharp pain, or 'stitch'. Another notable theory is that a stitch occurs due to an inadequate blood supply to the breathing muscles, which may explain why we often get stitches upon doing exercise after eating, as there is an increase in blood supply to the digestive system.

HOW DO BOATS BRAKE? DO THEY JUST PEDAL BACKWARDS?

Iris French

You're correct, though only for boats with pedals and propellers. Different types of boats have different ways of propelling themselves through the water. For boats with propellers, like motorboats and pedalos, the spinning propeller pushes water back, and this pushes the boat forwards. You can slow them by stopping the propeller spinning. If you spin the propeller backwards, the boat will push water forwards, and this will start to push the boat backwards and it will slow down a bit faster. But sailboats are different. If you want to completely stop your sailboat, don't forget an anchor or you'll drift away with the wind and currents.

WHAT IS A SLIPPED DISC AND WHY DOES IT HURT SO MUCH?

Geoff Poore

Your spine consists of 33 bones called vertebrae. Between each vertebra are circular pads, or discs, of connective tissue, which protect the vertebrae against shocks. The discs have tough cases that contain a gel-like substance. A slipped disc occurs when the gel protrudes outwards between the vertebrae. A damaged disc can put pressure on the entire spinal cord or on a single nerve fibre. This means that not only will a person with a slipped disc feel pain around the disc, but they could potentially also feel pain in every area a nerve fibre controls.

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Why does jelly wobble?

Cathy Lewis

Jelly is a soft semisolid containing gelatine. Gelatine is processed from the protein collagen found in skin and bones. The molecules in gelatine are intertwined in a triple helix. As they're mixed with hot water their bonds break, they unravel and become long, stretchy wriggly lines. As the water cools down, the helices start to reform and cross-linking occurs. This creates supermolecules that are so long they span across the whole jelly in a three-dimensional web. Water gets trapped in the spaces, giving jelly its wobble.

WHAT IS THE HARDEST FORM OF PLASTIC?

Freda Dixon

The hardest forms of plastic include plastic that has been mixed with other types of materials, such as a recent discovery by a team of Bangalore researchers where they strengthened ordinary plastic with nanodiamonds – incredibly tiny bits of diamond that are invisible to the naked eye – a sheet of layered carbon and tiny carbon cylinders. Also, polycarbonates, which are commonly known by the trademark name Lexan, are a type of thermoplastic polymer which, due to their durability, are widely used in bullet-resistant 'glass'. The softest forms of plastic can be runny, such as polymer clays, which are very malleable and can also include liquid forms.

LEGO hurts to step on, but isn't that hard

© Getty

How come some animals can change colour?

Li Wu

Flatfish take only a few seconds to change colour to blend with their background. Many other animals change colour to communicate. Chameleons are very good at this. They change to express sexual interest, readiness for a fight and to hide from predators. Some chameleons also change colour to help maintain their body temperature. Cuttlefish are masters of rapid colour and texture changes, meaning they can 'disappear' against their background as well as communicate complex messages. Their skin can change colour so rapidly that they produce waves of colour, controlling both the speed and detail of the patterns they can produce. Frogs generally don't change colour like this, though a few tropical species change colour as chameleons do to maintain a constant temperature.

Some animals change very slowly to match a seasonal change in their surroundings, simply by moulting and then growing different coloured hair. The rapid changes, however, are achieved with 'chromatophores' in the skin. In cuttlefish, there are tiny pockets of pigment such as melanin. These pockets are like pixels on an LCD screen. Simply by expanding or contracting these 'pixels', they can create almost endless blends of colours and patterns at will.

WHY DO WE SLEEPWALK?

Jack Duff

There's no direct evidence or cause as to the exact underlying mechanism for what makes us sleepwalk, but nevertheless there has been some interesting research into this area. You may be aware that there are different stages to the sleep cycle, and it has been found that physical activity – including sleepwalking – only occurs during the non-rapid eye movement (NREM) cycle of deep sleep.

It's thought that sleepwalking occurs due to normal physiological systems being activated by the brain at inappropriate times. Research has shown that there may be genetic involvement, which means tendencies to sleepwalk can be passed on from one generation to the next. It's also been observed that sleepwalking occurs most often in childhood, which could be to do with children spending more time on average in the deep-sleep part of the sleeping cycle. Several studies have shown that sleepwalking can be associated with stress, fever and sleep deprivation.

There's a chemical messenger in the brain called gamma-aminobutyric acid (GABA) which acts as a neural inhibitor to certain activity of the brain. It's been speculated that a lack of this, or an underdeveloped system which inhibits the activity of the brain, could be a cause.

SEND YOUR QUESTIONS TO: HOW IT WORKS MAGAZINE @HOWITWORKSMAG @HOWITWORKS@FUTURENET.COM HOWITWORKSMAG

Did you know?
Pollen is a very common allergy in humans

WHICH POLLINATION TECHNIQUE IS BEST: ABIOTIC OR BIOTIC?

Pete Morris

If a flower pollinates without the help of an organism, it's an abiotic pollinator, but if it pollinates with their help it's a biotic pollinator. Of all of Earth's flowers, only 20 per cent are abiotic – 98 per cent of which use wind to achieve pollination. Statistically, it's harder to reproduce in this way due to increased points of failure and dependence on weather, proximity and so on.

The other 80 per cent of plants are biotic pollinators, relying mainly on insects and birds to carry their pollen from one plant to another. This system is statistically more successful, with plants, birds and insects often co-evolving to unconsciously get the best for each other. The plants get pollinated while the organisms get energy from the nectar.

HOW DOES TOOTHPASTE FOR SENSITIVE TEETH WORK?

Barry Green

Imagine one of your teeth. It has two main sections: the crown above the gumline and the root below it. The crown comprises the following layers from top to bottom: enamel, dentine and the pulp gum. Nerves branch up from the root to the pulp gum. The dentine runs down to the root and contains a large number of tubules, or microscopic pores, which run from the outside of the tooth to the nerve in the pulp gum.

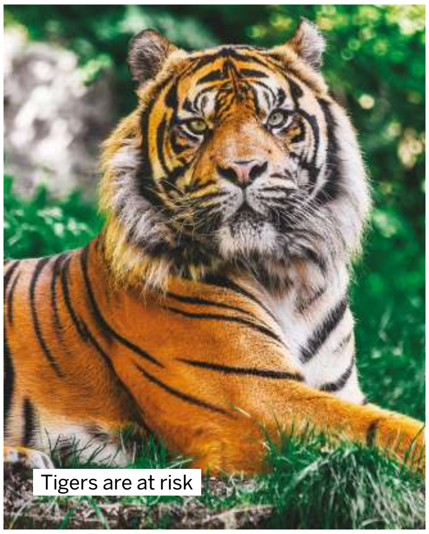
People with sensitive teeth experience pain when their teeth are exposed to something hot, cold or when pressure is applied. Their layer of enamel may be thinner and they may have a receded gumline, exposing more dentine – the enamel and gums therefore offer less protection, and this is what makes their teeth sensitive. Sensitive toothpaste works by either numbing tooth sensitivity or by blocking the tubules in the dentine. Those that numb usually contain potassium nitrate, which calms the nerves of the teeth. The toothpastes that work by blocking the tubules in the dentine usually contain a chemical called strontium chloride. Repeated use builds up a strong barrier by plugging the tubules more and more, leading to less sensitive teeth.

WHAT'S THE MOST AT-RISK SPECIES IN THE WORLD?

Hayley Parsons

The tiger is among the most at-risk species on the planet. Studies suggest that there may be just 3,900 wild tigers left in the world. Tigers are the largest of Asia's big cats. They're hunted and traded illegally for their pelts, bones and even their heads. In several countries, such as Indonesia, tigers are protected by law in an effort to prevent such illegal trade, and yet still more needs to be done to protect this majestic creature and its habitat.

By the end of the 20th century, Bali, Javan and Caspian tigers were all extinct. The six remaining subspecies – Amur, Bengal, Indo-Chinese, Malayan, South China and Sumatran – are all at risk of the same fate through poaching, illegal trading and loss of habitat.



Tigers are at risk

How are decibels measured?

Emma Barrett

What makes a particular noise louder than another is how much energy is put into producing it, and we measure and express this loudness in decibels. We can measure decibels with a decibel meter. Sound is a vibration passed from one molecule to another. When it reaches our ears, the vibration is converted into sound by our brain. The larger the vibration, the louder we interpret the sound. A decibel meter contains a very sensitive microphone that acts a little bit like our eardrums and measures the size of the vibration caused by the sound wave. This is then interpreted into an electrical signal and gives out a reading in decibels. Essentially, the more the microphone vibrates, the larger the decibel reading.

© Getty

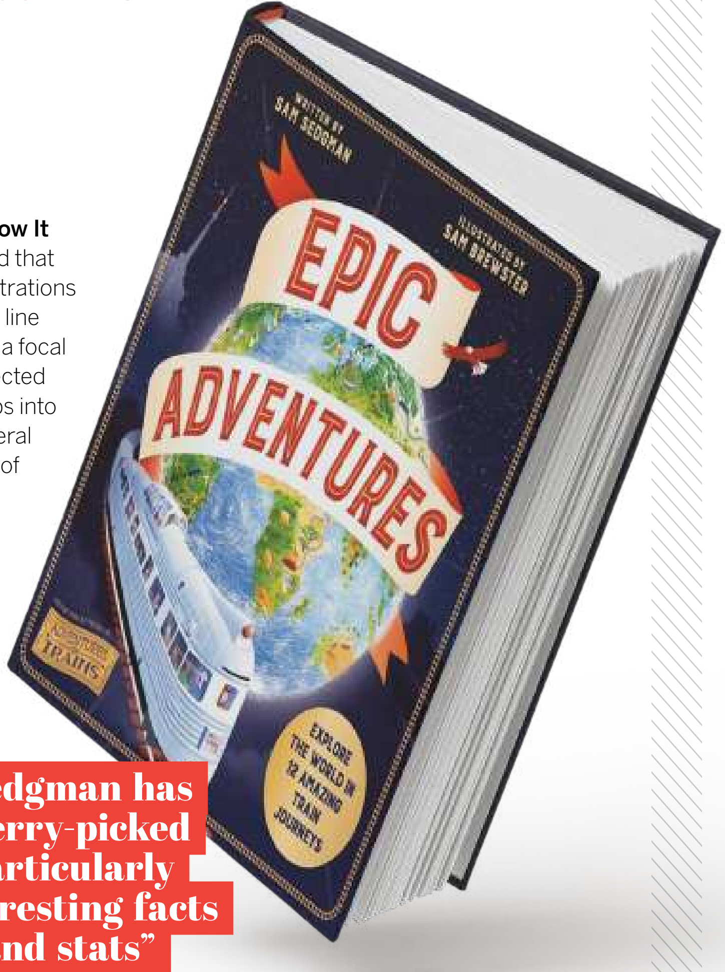
THE LIBRARY

The latest book releases for curious minds

EPIC ADVENTURES

SIX CONTINENTS AND 34 COUNTRIES ON 12 INCREDIBLE TRAIN JOURNEYS

AUTHOR **SAM SEDGMAN**
ILLUSTRATOR **SAM BREWSTER**
PUBLISHER **PAN MACMILLAN**
PRICE **£12.99 / $19.99**
RELEASE **OUT NOW**


WRITTEN BY SAM SEDGMAN
ILLUSTRATED BY SAM BREWSTER
EPIC ADVENTURES
EXPLORE THE WORLD IN 12 AMAZING TRAIN JOURNEYS

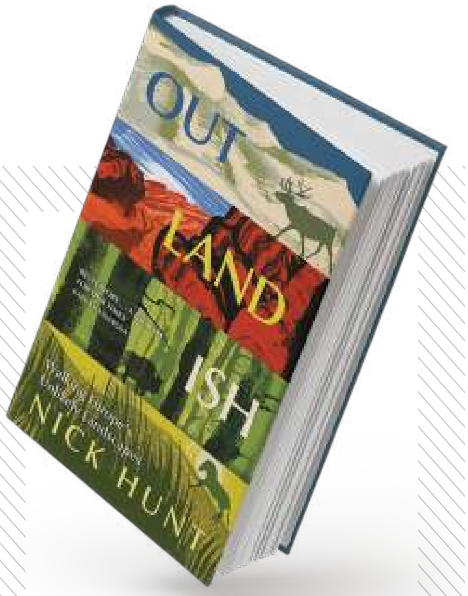
If you're a regular reader of **How It Works**, you may have noticed that we like maps, annotated illustrations and cutaways. Even a simple line drawing can be brought to life and made a focal point on the page when the reader is directed effectively around it. *Epic Adventures* taps into that same idea, taking the reader on a literal journey around the world across dozens of countries and hundreds of cities on 12 different train journeys that span tens of thousands of miles.

Along the way, we don't just stop at stations and peer out the window from a comfortable seat. Award-winning author Sam Sedgman leads us into wild and wonderful locations, annotated on beautifully drawn maps, such as the abandoned mountaintop city of Machu Picchu in Peru, along San Francisco's Golden Gate Bridge and to the vital strait of the Bosphorous between the Black Sea and the Mediterranean via the world-famous Orient Express. With every train journey, *Epic Adventures* focuses on an interesting location somewhere along the tracks, portraying wonderfully vivid scenes in striking colours, such as the enormous and bustling Tokaido Shinkansen train station in Japan or the stark beauty of the Salar de Uyuni salt flats in Bolivia.

> **"Sedgman has cherry-picked particularly interesting facts and stats"**

Sedgman has cherry-picked particularly interesting facts and stats for these special illustrations: the Bolivian salt flats contain 70 million tonnes of salt, for example, and are so big and flat that scientists can use them to check the height of satellites in space. And the Tokaido Shinkansen line is home to the superfast bullet train that's renowned for its punctuality – so much so that if it's more than five minutes late, passengers are given a delay certificate to prove it to their boss or teacher.

Sedgman signs off by giving the reader a little insight into the passion he has for train journeys as a way of exploring and discovering the world. *Epic Adventures* is a compelling read that could easily inspire wanderlust in adults, let alone the school-age readers it's intended for.



OUTLANDISH

WALKING EUROPE'S UNLIKELY LANDSCAPES

AUTHOR **NICK HUNT**
PUBLISHER **JOHN MURRAY PRESS**
PRICE **£16.99 / $21.95**
RELEASE **OUT NOW**

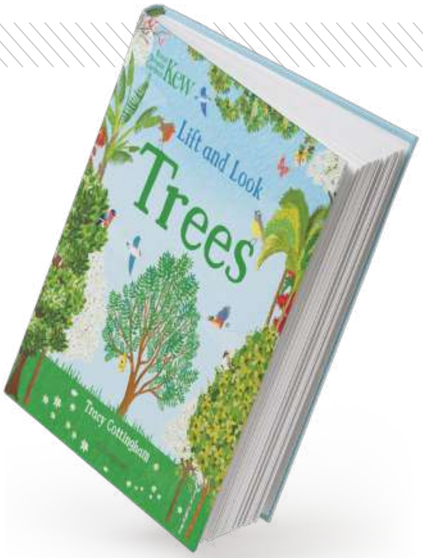
Acclaimed travel writer Nick Hunt has once again penned a travel book full of wit and insight that makes you feel as though you're right beside him as he treks through some unusual and unique places in Europe. Hunt explores a patch of tundra in Scotland, a jungle in Poland, a desert in Spain and a steppe in Hungary, going far beyond the remit of other travel books to offer a first-hand account of extraordinary places in Europe along with his personal experiences and gentle humour.

Along his travels, Hunt makes sure to emphasise the environmental impact climate change is having on natural landscapes and the importance of preserving these seemingly 'misplaced' places. Full of fascinating facts about the history and mythology of each location and its wild inhabitants, this is a must-read for any travel enthusiast. You'll struggle with the urge to immediately go out and have your own travel adventures after reading this book.

KEW: LIFT AND LOOK TREES

INTERACTIVE ARBORETUM

AUTHOR **TRACY COTTINGHAM**
PUBLISHER **BLOOMSBURY**
PRICE **£7.99 / $16.99**
RELEASE **OUT NOW**



This is one of the latest books in the Lift and Look series by the Royal Botanic Gardens, Kew. Packed with illustrations, it's a visual treat for a very young audience. Children can learn about some of the many trees that can be found on Earth, along with their seeds, flowers and fruits. Illustrator Tracy Cottingham has included some charismatic critters that call the trees home and shows how trees change through the seasons, with simple language and descriptions for early readers aged three or above. This book is a nice way to introduce your young one to the wildlife in your garden and a great addition to a walk through the woods to learn more about nature.

Kew: Lift and Look Trees is part of a series of fun and engaging children's nature books which include topics such as bugs, birds and flowers.

AROUND THE WORLD IN 80 MUSICAL INSTRUMENTS

HOW DIFFERENT CULTURES MAKE MUSIC

AUTHOR **NANCY DICKMANN**
ILLUSTRATOR **SUE DOWNING**
PUBLISHER **WELBECK PUBLISHING GROUP**
PRICE **£14.99/ $17.95**
RELEASE **OUT NOW**

There are so many ways to make music. Around the world, each country has its own unique traditions, ancient musical instruments and popular songs. It's unlikely that you've experienced them all, but this book will make you feel like you have. From common wind, string and percussion to the most unusual instruments, each one is given a detailed overview, such as the location of its origin, the history behind its beginnings or the unexpected materials some are built from, with striking illustrations portraying size, how they're played and some of their beautifully crafted designs.

Some instruments are unique to certain religions, such as the Buddhist standing bell, while others come with traditional rules. Did you know that the stringed imzad of the Tuareg people of the Sahara is only played by women? Or that the Appalachian dulcimer is an instrument from the American mountains that often needs two people to play?

You may never have heard of these instruments before, but this book will explain everything while providing new facts about familiar ones, too. If you want to try your hand at some of these instruments, *Around the World in 80 Musical Instruments* includes instructions to make your own at home. Equipped with the knowledge, inspiration and your own handmade versions, you can share in the love of music found in every country.

> **You may never have heard of these instruments before, but this book will explain everything**

MONTH-BY-MONTH GARDENING GUIDE

DAILY ADVICE FOR GROWING FLOWERS, VEGETABLES, HERBS AND HOUSEPLANTS

AUTHOR **FRANZ BOHMIG**
PUBLISHER **TIMBER PRESS**
PRICE **£21.99 / $27.95**
RELEASE **OUT NOW**

This in-depth gardening book provides tips and season-specific guidance that will give your plants the best chance of thriving. Whether you're looking for general advice, such as what materials to use to air your compost and how to dig trenches to benefit newly planted trees, or you want to help your plants blossom in a specific month of the year, this book has 1,388 tips to make you a better gardener.

This long list is categorised into months and types of plants to help you find the information you seek, then a detailed series of tables detail how to improve growth in specific soil types and the nutrient, rotation and pH requirements for a large selection of commonly grown vegetables. The extensive second half of the book includes equally vital information about most of the ornamental plants in your garden, labelled with both their botanical species name and common English name.

Month-by-Month Gardening Guide provides exactly what it claims in the title and can help a gardening novice give their garden more life or fine-tune the skills of a pro.

BRAIN GYM

Give your brain a puzzle workout

Sudoku

Complete the grid so that each row, column and 3x3 box contains the numbers 1 to 9

EASY

	2			9		8		6
6				2	4		3	
	3			1				
2	1		4					
4	6	8	9		5	1		
7	9		1		2			3
1	5	6					4	
3	7	2	6		1		9	
8		9	7	5	3		2	

MEDIUM

	3	6				7		
1		9			2	8		
			4	5		3	9	1
3						1		
	2	7		3			8	4
		1						
	5					2	3	
	6	3	9	2			1	
2		8	6				5	

HARD

		4	2		9			
				3	7			
	2						1	
	5	3	8		6		7	
	4	6		2		3		8
								9
4			5		2		8	
			1	7				
		9						7

Word search

Find the following words

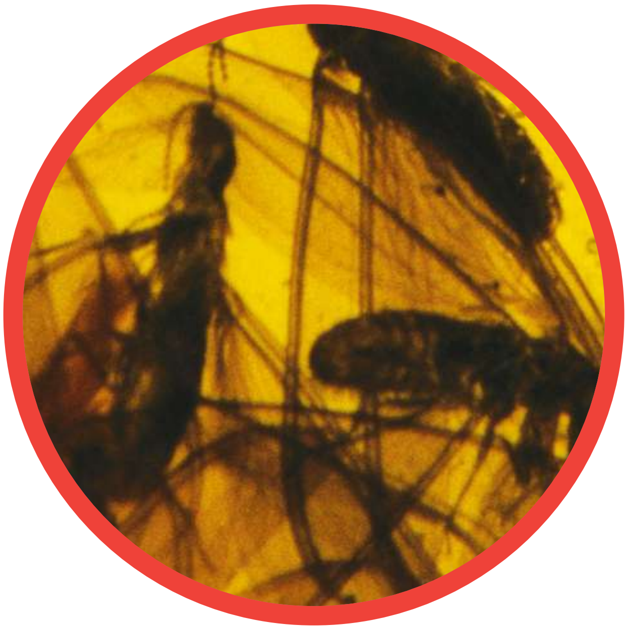
- CORONAL
- NATO
- KETTLE
- GLACIER
- TOXIN
- HACK
- NANO
- VEIN
- VENDING
- EJECTION
- DRUNK
- GRAPHENE

C	H	G	R	A	P	H	E	N	E	M	W	G	H	W
O	S	P	Z	G	C	B	J	K	W	K	O	A	J	Z
R	I	H	E	C	N	A	E	W	V	E	I	N	U	R
O	A	A	T	N	I	A	C	A	E	T	U	X	D	V
N	O	C	R	S	E	H	T	K	E	T	A	N	B	M
A	M	K	U	S	K	E	I	J	A	L	A	R	S	O
L	S	I	E	K	A	Z	O	C	G	E	U	F	A	Q
I	H	A	N	A	E	T	N	J	O	T	C	F	E	N
Y	Q	U	E	E	A	U	I	B	I	E	L	P	A	L
I	R	T	O	X	I	N	A	R	O	R	D	N	F	A
D	H	E	L	E	Q	N	E	T	R	P	O	X	O	R
S	J	K	L	R	Y	B	A	A	Q	A	X	X	R	V
E	C	p	A	Z	X	N	N	S	E	N	D	A	B	A
A	V	E	N	D	I	N	G	E	E	N	T	I	N	G
R	A	S	S	O	D	R	E	I	C	A	L	G	X	Y

What is it?

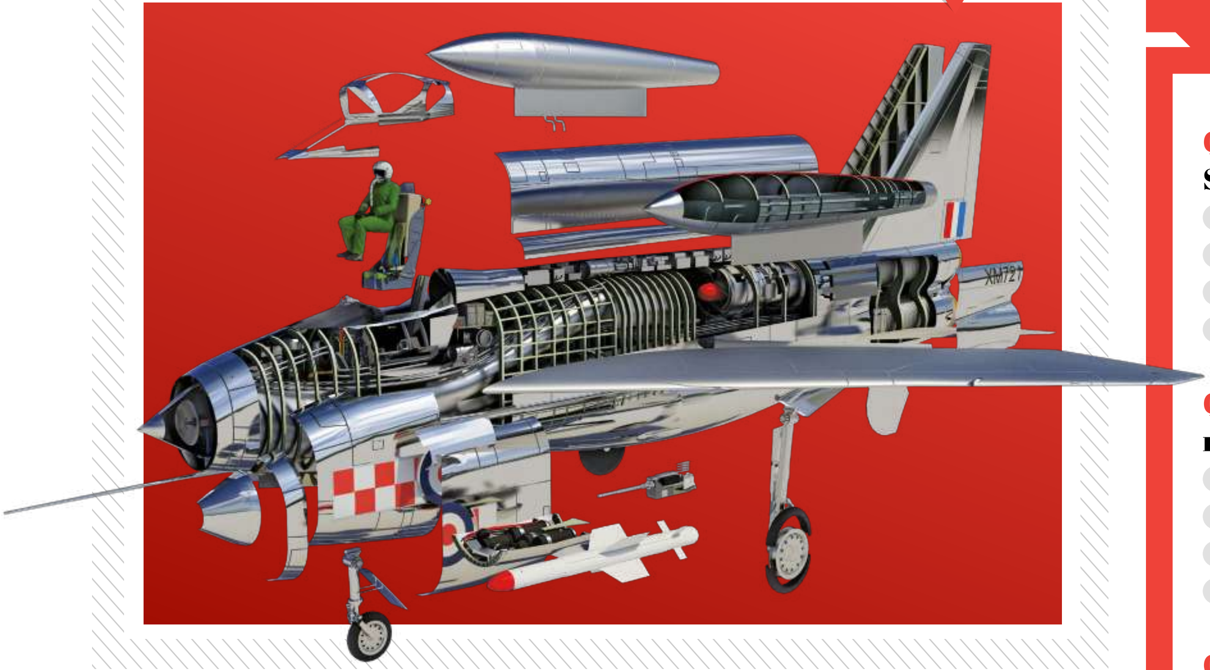
Hint: A sticky sap and an insect trap

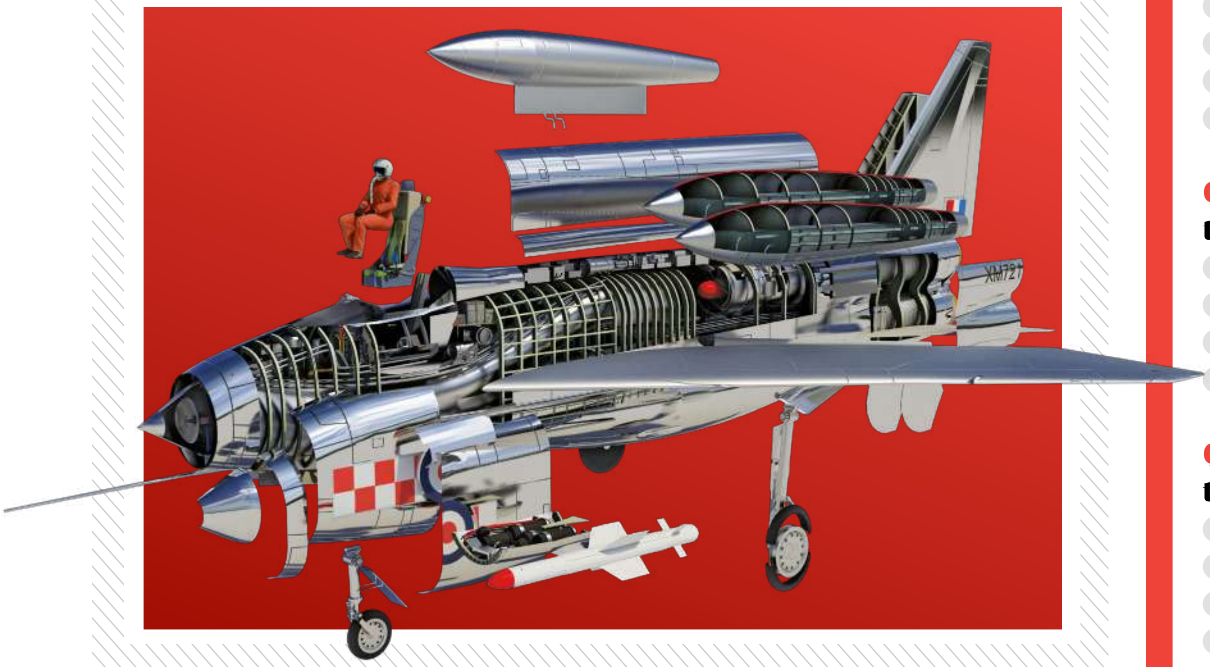
A



Spot the difference

See if you can find all six changes between the images below





Answers

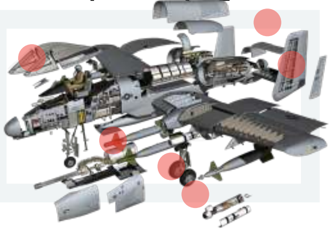
Find the solutions to last issue's puzzle pages

Q1 FRICTION
Q2 MARIE CURIE
Q3 BAROMETER
Q4 RED
Q5 DRAGONFLY
Q6 HEART

What is it?

DEW

Spot the difference



QUICKFIRE QUESTIONS

Q1 Which International Space Station module was first?
○ Unity
○ Harmony
○ Kibō
○ Zarya

Q2 Which of these foods is the most protein-rich?
○ Eggs
○ Lentils
○ Chicken
○ Apples

Q3 Which of these is a NATO member country?
○ Australia
○ China
○ France
○ Russia

Q4 What's the biggest river in the world by volume of water?
○ Nile
○ Amazon
○ Yangtze
○ Mississippi

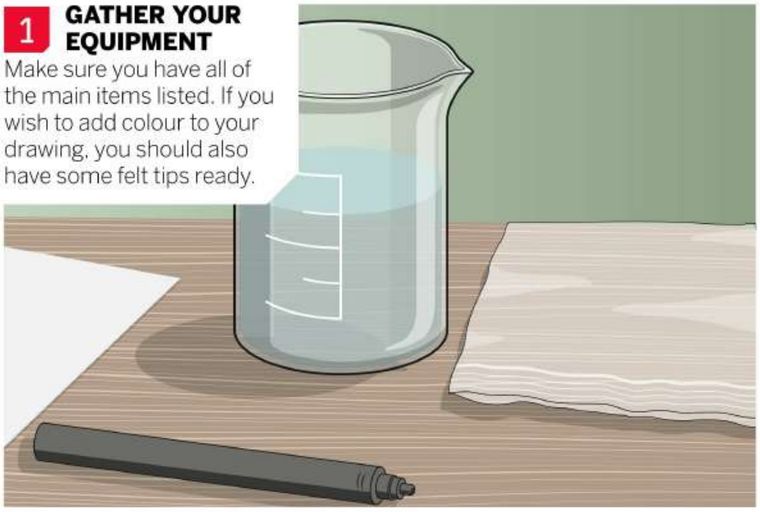
Q5 Where in your body is the tympanic membrane?
○ Eye
○ Ear
○ Nose
○ Throat

Q6 Which of these foods do mice actually hate?
○ Peppermints
○ Peanut butter
○ Cheese
○ Chocolate

© Getty

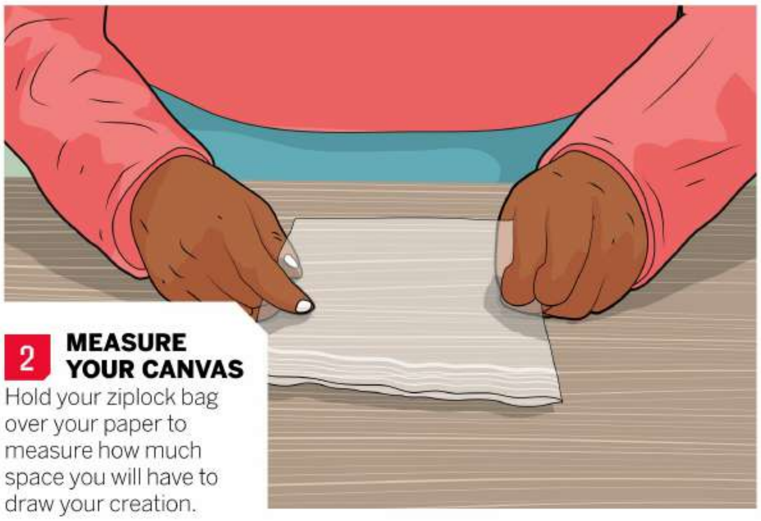
MAKE YOUR DRAWING DISAPPEAR

Your artwork will vanish before your eyes with this refraction trick



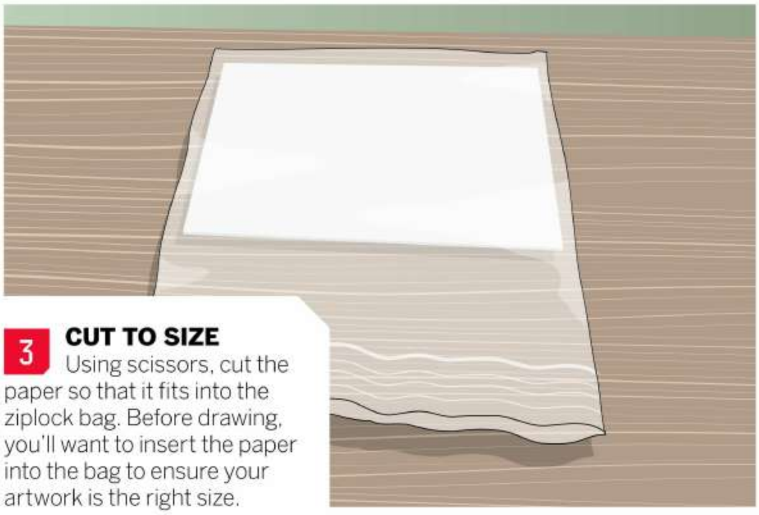
1 GATHER YOUR EQUIPMENT

Make sure you have all of the main items listed. If you wish to add colour to your drawing, you should also have some felt tips ready.



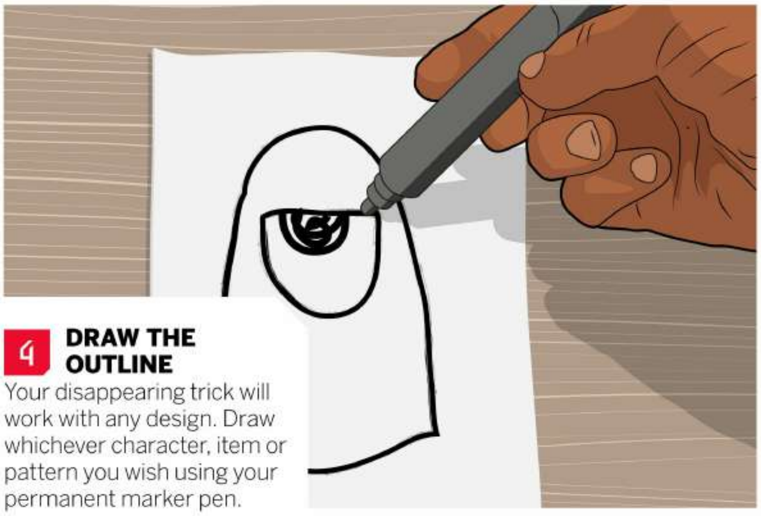
2 MEASURE YOUR CANVAS

Hold your ziplock bag over your paper to measure how much space you will have to draw your creation.



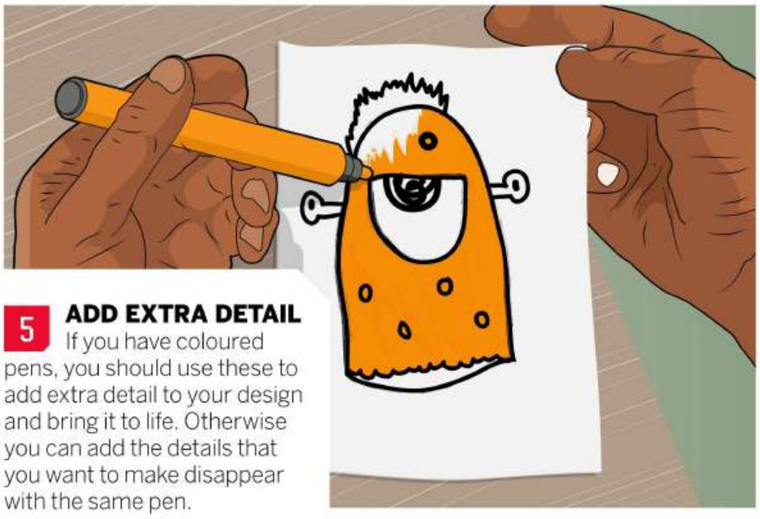
3 CUT TO SIZE

Using scissors, cut the paper so that it fits into the ziplock bag. Before drawing, you'll want to insert the paper into the bag to ensure your artwork is the right size.



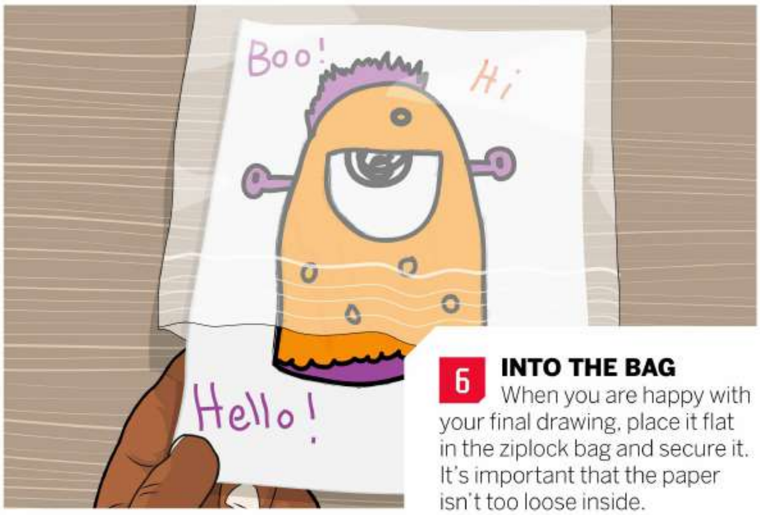
4 DRAW THE OUTLINE

Your disappearing trick will work with any design. Draw whichever character, item or pattern you wish using your permanent marker pen.



5 ADD EXTRA DETAIL

If you have coloured pens, you should use these to add extra detail to your design and bring it to life. Otherwise you can add the details that you want to make disappear with the same pen.


Boo!
Hi
Hello!

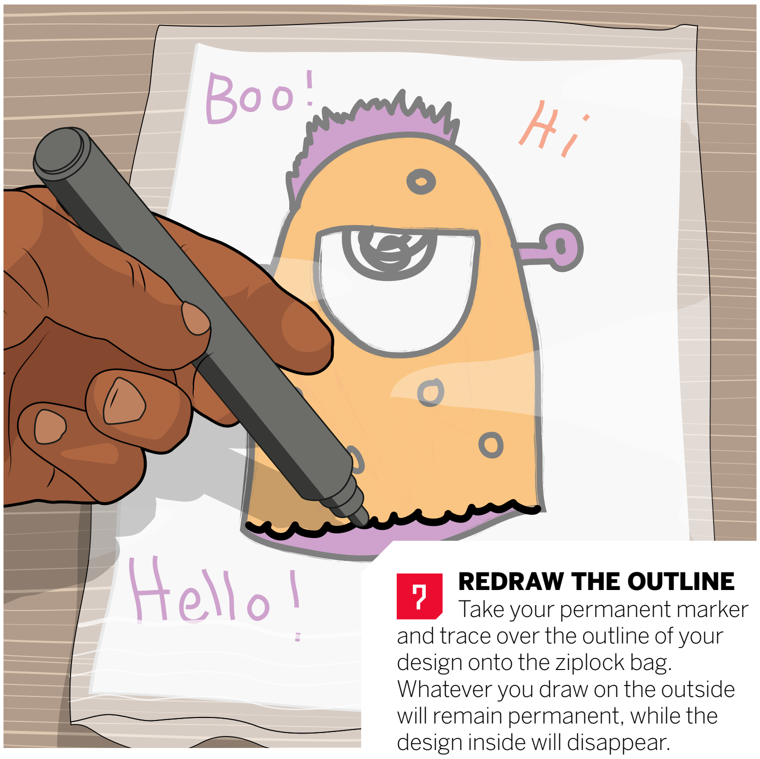
6 INTO THE BAG

When you are happy with your final drawing, place it flat in the ziplock bag and secure it. It's important that the paper isn't too loose inside.

SEND YOUR IDEAS TO: HOW IT WORKS MAGAZINE @HOWITWORKSMAG @HOWITWORKS@FUTURENET.COM @HOWITWORKSMAG

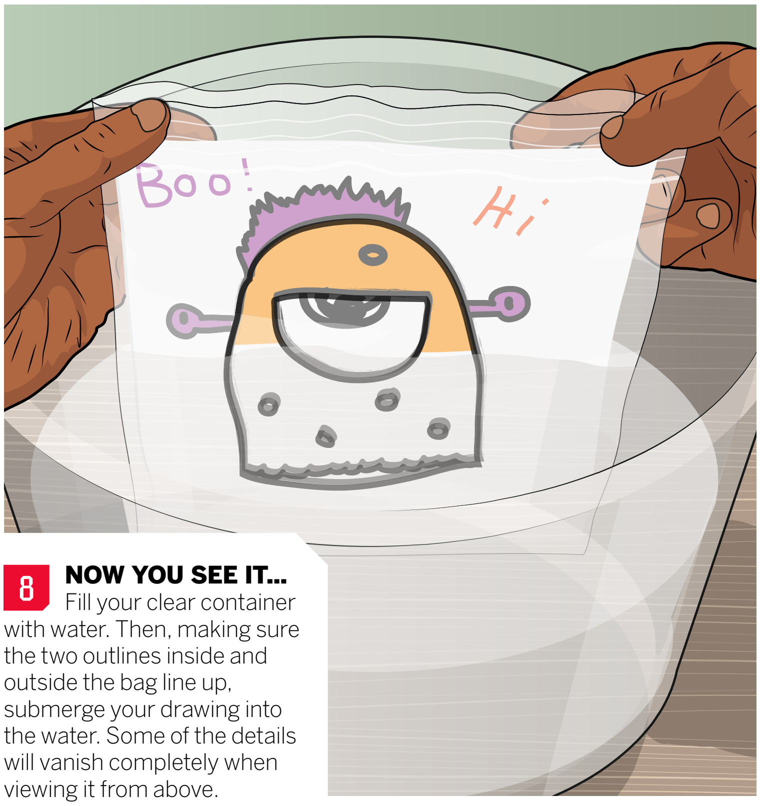
KIT LIST

- A large clear container
- Water
- Permanent marker
- Ziplock bag
- Paper
- Scissors


Boo!
Hi
Hello!

7 REDRAW THE OUTLINE

Take your permanent marker and trace over the outline of your design onto the ziplock bag. Whatever you draw on the outside will remain permanent, while the design inside will disappear.



8 NOW YOU SEE IT...

Fill your clear container with water. Then, making sure the two outlines inside and outside the bag line up, submerge your drawing into the water. Some of the details will vanish completely when viewing it from above.

SUMMARY

The physics behind this trick involves light's interaction with different objects. Every object that you see is reflecting light, meaning that when some of the drawing disappears, the light hitting it is not returning to your eyes. Why is this? When light passes through a liquid to a gas – in this case the water to the air – the direction that the light is travelling changes. This is called refraction, and it happens because the water and air have different densities.

Light that hits the water at an angle greater than 90 degrees doesn't leave the water again when it reaches the transparent ziplock bag, but is reflected back through the water. This total internal reflection takes place in mediums such as water and glass. Because of this, when the drawing is in the water, you can see the light that has bounced off the outline of the drawing on the outside of the bag, but not the colourful or patterned drawing on the inside. When taken out of the water, this internal reflection doesn't take place, so the light reveals the drawing again.

Had a go? Let us know!

If you've tried out any of our experiments – or conducted some of your own – let us know! Share your photos or videos with us on social media.

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NEXT ISSUE
Grow bacteria at home on your own petri dish

© Illustrations by Ed Crooks

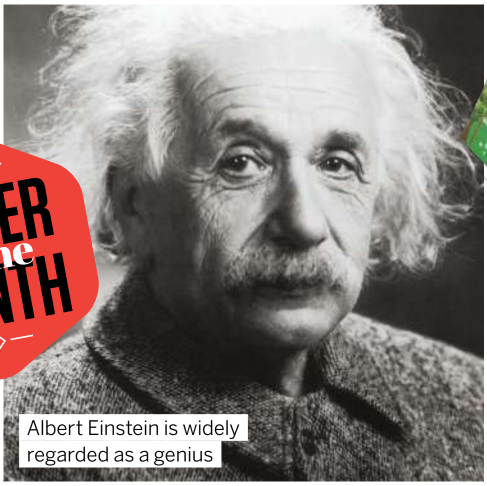
INBOX

Speak your mind

LETTER of the MONTH

MAKING A GENIUS

Dear **HIW**,
If someone isn't a genius already, can they make themselves become one by training thought patterns as well as reading a great deal? Thought that would be a terrific question to be published in a future edition.
Bill Miller


Albert Einstein is widely regarded as a genius

Thanks for your question, Bill. The most common definition of a genius is someone with extremely high intelligence. Mensa, the international society for members of exceptional intelligence, regards geniuses to be those in the top two per cent of the population. However, being a genius is more than storing impressive amounts of information in your memory. Being a genius is more to do with the way the brain is programmed to work.

When studying the brain of Albert Einstein, for example, scientists found that he had extra folding in the grey matter of his brain – this is the part that controls conscious thinking. While it may not be possible to train yourself to Einstein's level of genius, there are strategies you can use to maximise the potential of your brain. These include training your memory, reading more and consistently to maximise your cognitive abilities and giving yourself periods of time to think without distractions.

Because the definition of a genius isn't so clear-cut, there's no set method to becoming one. Additionally, being a genius doesn't merely involve passing an IQ test. There are different types of geniuses, including creative and sporting geniuses, who aren't able to show their skills through conventional tests.

Lift and Look
Trees

WIN!

AN AMAZING PRIZE FOR LETTER OF THE MONTH

LIFT AND LOOK TREES

Who lives in trees? What do trees look like as the year goes by? Lift the flaps to discover red autumn trees, leafless winter trees and even lots of things that can fall from trees.

CASTLE QUERY

Dear **HIW**,
What's the oldest castle that's still there today?
Henry Patterson

The Citadel of Aleppo is considered to be the world's oldest castle, dating back to 3000 BCE. Located in northern Syria, some of the large, mediaeval buildings were rebuilt when Nur ad-Din ruled Aleppo in the 10th century. However, the oldest castle that's still in use is Windsor Castle in England, which was constructed in 1070 CE. Since it was built by William the Conqueror, the castle has remained a residence for royals. Over time, some elements have been adapted based on the desires of the residing kings and queens.

The Citadel of Aleppo has stood for thousands of years

WHERE'S THE WATER?

Dear **HIW**,
Some animals seem to be able to sense their way to water. How? Also, why can't humans do this?
Stephen

Elephants can sense water from over 12 miles away

Different animals' senses vary significantly, but many have evolved to be able to find water, as it's essential for most living creatures. Some animals can smell water sources from many miles away. The water itself is odourless, but it reacts with the plants, bacteria, chemicals and minerals surrounding it. By learning the smells of the soil and plants associated with water sources, animals can follow their nose to moisture.

Evidence suggests that larger mammals are more likely to remember the location of water sources and return to the same ones. This includes humans. Scientists think that when we began to walk on two feet, our water requirements increased. At this stage in our evolution, humans developed more eccrine glands. We began to lose more water than other mammals through sweating and needed to be based near reliable water sources for survival. During this transition, modern humans no longer needed to be able to smell water sources.

NEXT ISSUE
ISSUE 165
ON SALE 9 JUN 2022
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Australia is five per cent of the world's land mass

COMPARING COUNTRIES

Dear **HIW**,
I recently went to Australia, and after looking at it on the map I realised how huge it was in comparison to my country, the UK. Is it really as big as it looks on the map?
Jen Aken

Australia is definitely much larger than the UK, being the sixth-largest country in the world following Russia, Canada, China, the US and Brazil. At 2,941,300 square miles, Australia is about 31 times bigger than the UK, which is 93,628 square miles. This means it's actually even greater in size compared to the UK than it appears on the world map.

Wheelchair rugby players participating in the 2020 Invictus Games

HISTORY OF THE INVICTUS GAMES

Dear **HIW**,
Why did Prince Harry start the Invictus Games?
Matthew Collins-Cook

The Invictus Games see wounded servicemen and women take part in a selection of sports, with the aim to give back to those who have served their country and help them in the recovery process. They began after Prince Harry witnessed the Warrior Games. This is a similar event run by the US Army. While he was in attendance, Harry saw the benefits of sport for those rehabilitating after injury and worked with the Ministry of Defence to bring the idea to the UK.

WE ASKED YOU

This month on social media, we asked you: If you could invent any tiny robot, what would it do?

BETHANY P

It would attack pollen grains around me to stop hayfever

@NOBODYNOONE71

Tackle cancer

CARON J

Detect and kill any harmful microorganisms like COVID-19 from surfaces or the body

@AESTHETICALLY_AJ

A tiny defibrillator robot on the heart that could automatically send electric shocks in emergencies

@MAIA_H3

Clean my glasses lenses

@DOODLENEWS

A flying camera that could follow you and capture significant events

© Getty

HOW IT WORKS

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FAST FACTS

Amazing trivia that will blow your mind

70 YEARS

Queen Elizabeth II is Britain's longest reigning monarch

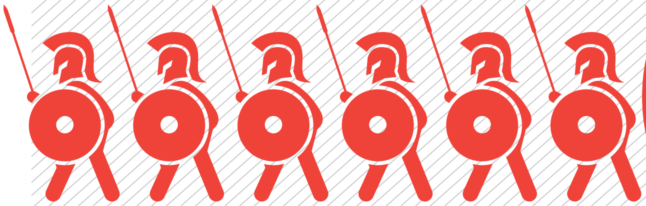
$150 MILLION

The staggering cost of a NASA spacesuit from 1974 if made today

THE FIRST COMPUTER VIRUS WAS MADE IN 1971 AND WAS CALLED CREEPER

450 DEGREES CELSIUS

The scorching temperatures at the surface of Venus could melt lead



25 MILES A DAY

With the invention of roads, the Roman army could march huge distances

500

The liver has hundreds of different functions

YOUR DNA IS STORED IN THE NUCLEUS OF EVERY CELL IN YOUR BODY

2,208

The number of people on the Titanic when it sank

2010

In this year, broadband finally delivered data faster than a carrier pigeon

Your appendix isn't useless: it replenishes gut bacteria

500 METRES

Height of the tallest recorded tsunami in history

© Getty

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- Stickers Included
- Rolling Wheels
- Pre-Coloured
- Push Fit

J6036
FORD MUSTANG GT

QUICKBUILD
Ford Mustang GT
No Glue - No Paint - Just Build!
6+

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Rolling Wheels
Pre-Coloured
Push Fit
ACTUAL SIZE
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184 mm
Ford Mustang GT
Designed and made in the UK
www.airfix.com/quickbuild

Ford Mustang GT
Build an Iconic Model

The sixth generation Ford Mustang (S550) is the current iteration of the Mustang pony car manufactured by Ford. In departure from prior Mustang models, the sixth generation Mustang includes fully independent rear suspension on all models, as well as an optional 2.3L EcoBoost turbocharged and direct injected four-cylinder engine. The new Mustang was introduced as a 2015 model year vehicle, marking the fiftieth anniversary of the Ford Mustang, which was revealed as a 1965 model year vehicle on April 17, 1964. The sixth generation is also the first Ford Mustang to be marketed and sold globally, and represented the first time that factory right hand drive Mustangs were produced in addition to the left hand drive models.

This vehicle has already become a true icon. You can create your own version at home with this Airfix QuickBuild kit. Recreate brilliant scale models of a wide variety of iconic aircraft, tanks and cars with QuickBuild kits. No paint or glue is required, the push together brick system results in a realistic, scale model that is compatible with other plastic brick brands.

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